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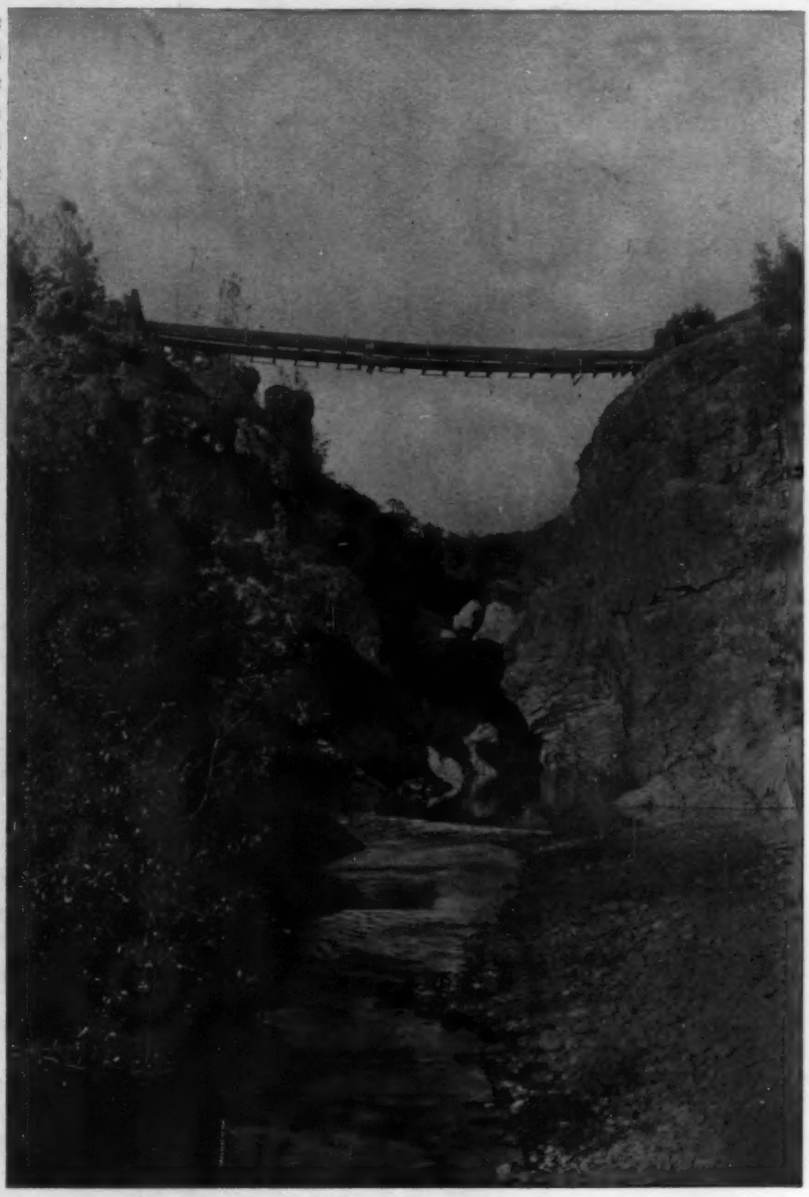
The Yuba-Marysville Transmission.

JUST one hundred and twenty-five days, or four moths and five days, elapsed from November 15th, 1897, when the Yuba Power Company begun work on the electric transmission about to be described, until March 21st, 1898, when the installation was placed in operation, and the work accomplished during that brief period included the entire rebuilding of the thirty odd miles of water system; the survey, location and clearing of the power house, pole line, two sub-stations, and the city distribution for over five thousand lights, in addition to the erection of all the hydraulic and electrical equipments of the plant. In no case was thoroughness and stability sacrificed to gain time, and the Yuba-Marysville transmission holds the well-earned distinction of having been the quickest installation of the kind ever accomplished.

Fifty years ago the Yuba River found no barrier in flowing along its natural course, but hydraulic mining long since shoaled the stream until now hundreds of thousands of acres of the fine farming lands of the surrounding counties would be innundated each year were it not for the great levees than have been thrown up to confine the river. Indeed where the Yuba was a few rods wide in the '50s, it has a width in some places of two or three miles at present, and on the low lands it pursues its sluggish, muddy way over a shallow, silty course to a junction with the Sacramento. After seeing the immeasurable quantities of soil and slickens that are deposited along the rivers of some of the valleys of California, one does not further wonder what has become of the earth which constituted the mountains that the early miners washed down and apparently removed from off the face of nature.

It is along one of the levees of the Yuba river that the road from Marysville to the power house of the Yuba Power Company follows for the first five miles of its route, then another five miles through an open country brings one to the foothills where the real beauty of the drive begins and this beauty grows upon one with ever heightening interest as the elevation increases. California was in all its spring-time glory when we went over the Yuba Transmission and the trip, though early in April, was a prolonged May-day outing. The mountain sward was as green and trim as any lawn; the oaks cast inviting shades and the luxurient wild flowers made the country so delightful that the twenty-two mile drive sped quickly. The road follows the pole line for perhaps two thirds of the way, for, while the country thoroughfare follows



THE "INVERTED SIPHON" CROSSING DRY CREEK.

along the easiest practicable grades, the pole line takes a more direct route as is evidenced in the fact that its length is nearly four miles longer than that of the pole line.

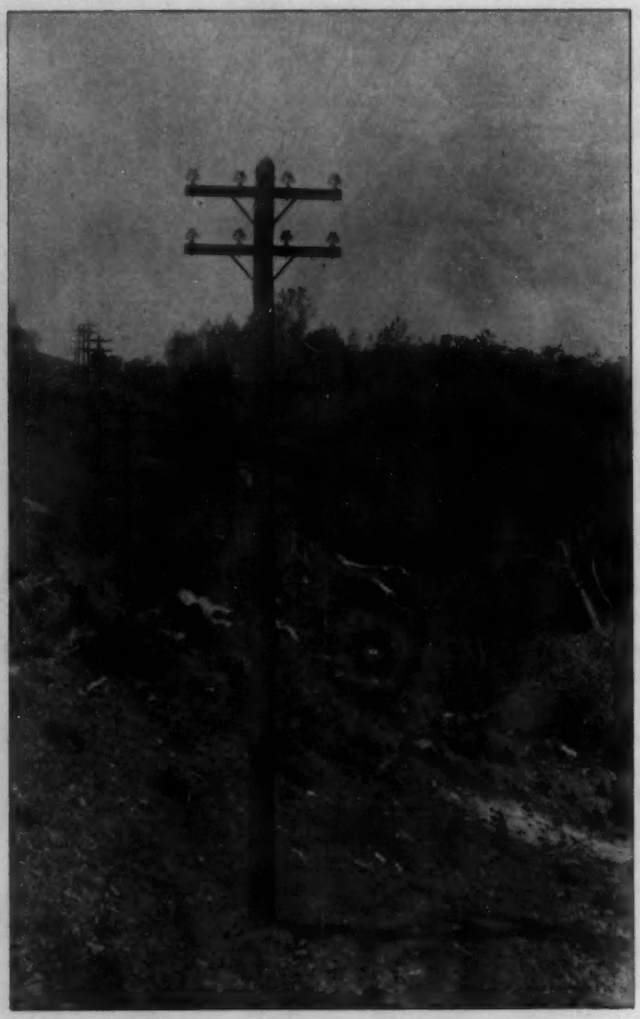
The Pole Line.

The pole line is of a very substantial type of construction, being of round timber, specially selected for the Yuba transmission. The poles vary from thirty to forty feet in length according to location, and measure 12 inches at the butt by seven inches at the top. The kind of wood best suited for poles has long been an open question, but the concensus of opinion points to about

How the Transmission Crosses Dry Creek.

an equal choice between cedar and spruce. For this reason, both varieties were used in the Yuba pole line in equal quantities, in fact cedar and spruce poles alternate on the line so that their respective qualifications, under equal conditions of service, may be determined. The butts of the poles are tarred and one sixth of the pole length is in the ground. The poles are set 120 feet apart, or 44 to the mile, and inverted "T" stubs are used for guying at all corners or bends in the line. A right of way 100 feet wide has been cleared through the wooded portions of the route of the pole line, amounting probably to less than one-half its length, the remaining portion being over open prairie or farming lands.

The construction of the pole line embodies all the best features of most improved practices in transmission work. Four-pin, pine cross arms measuring 3x4 inches by 5 feet are used, and these are gained into the poles, iron-braced, and painted with P. & B. insulating and waterproof paint. A single four wire, two phase circuit of No. 6 medium hard drawn copper of Roebling manufacture extends from the power house to the sub-station at Marysville, a distance of 18 1-2 miles by the pole line, while a second similar circuit is independently carried from the power house to the sub-station in Brown's Valley, 7 1-4 miles distant. These two, two phase circuits, consisting of eight wires, run along the main pole line to the "Christmas tree," as the corner intersection pole with its 32 power insulators and 12 telephone insulators, is called. Thence, the main line continues on to Marysville and the Brown's Valley circuit is taken up to the sub-station in the Webb Mine over a pole line that is identical in its features of construction and materials with the main line. The "Christmas tree" is six and a half miles distant from the power house, hence the branch line extending to Brown's Valley has a length of three-fourths miles. The four power cross arms on the "tree" are boxed in double and each carry eight "Locke" triple petticoat glass insulators measuring 5 1-2 inches across the base and weighing 5 lbs. each, while the telephone cross arms, placed five feet below the lower power cross arm, each carry six "Locke" glass petticoat insulators, all as shown in the illustration on page 1460. The telephone line is of No. 12, B. & S. gauge bi-metallic wire, transposed every tenth pole. The telephone cross



A Characteristic View of the Pole Line.

arms carry the regular long distance wies of the Sunset Telephone and Telegraph Company as well as the private line of the Yuba Power Company.

The insulators and the method of mounting them are deserving of special consideration as they are believed to

embody the results of the experiences of California transmissions regarding the line for high potential work. The Yuba Power Company is operating a line potential of 16,700 volts, which is the highest pressure of any California transmission up to the present, that between Newcastle and Sacramento, at a trifle under 16,000 volts, being the next highest. To support the Yuba lines, it was determined to use "Locke" glass insulators of the type defined, on one-half inch steel-locust pins, fitted with the "Locke" porcelain base, the latter being given a coat of P. & B. paint at the time of painting the cross arm. The line wires are secured to the sides of the insulators by standard Western Union long ties, and the power lines are not transposed, except a half-twist in the Brown's Valley line at a point midway between the power house and the "Christmas tree." The Brown's Valley circuit has a capacity of 750 kw. at a line loss of four per cent., and the Marysville circuit has an equal capacity but with a line loss of ten per cent.

AT THE POWER HOUSE.

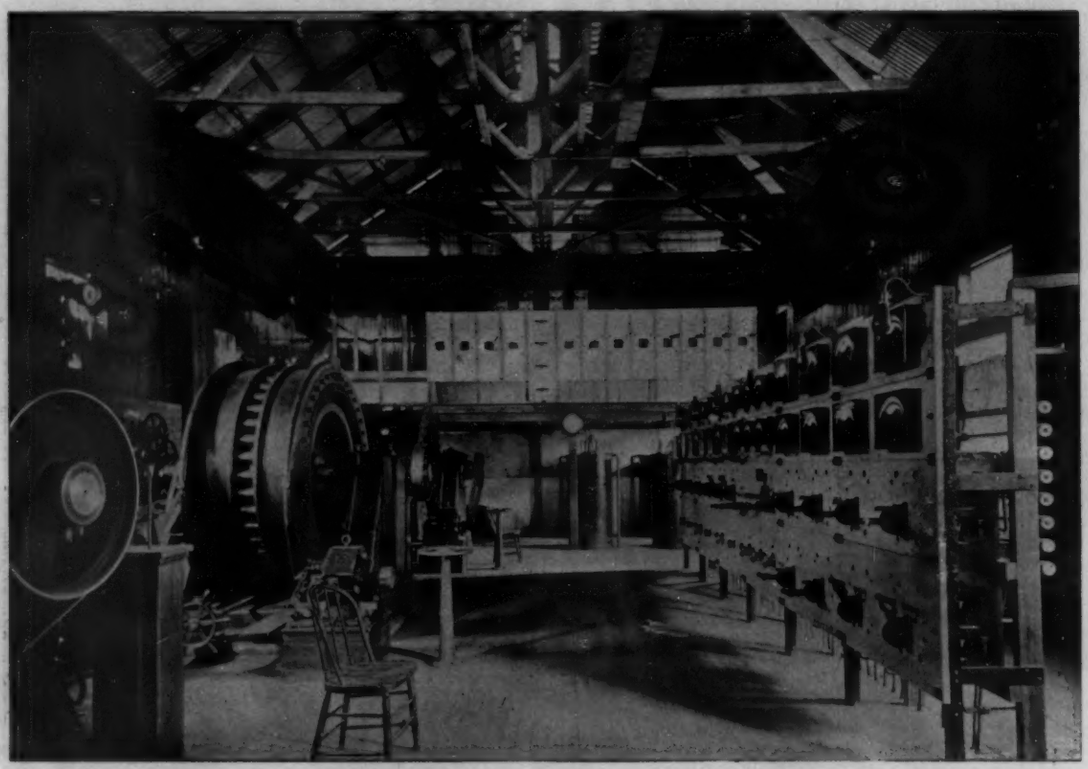
The method of crossing Dry Creek forms an interesting feature of the line construction. When "Dry" Creek, is a poser, for it always carries more water than many so-called rivers of California and in winter it oft-times becomes a raging torrent, unmindful alike to the welfare of bridges or of those who tempt fate at its fords. The bridge illustrated on page 156 is built on three massive concrete piers which will successfully withstand any flood, and it is to the lower side of the center one of these piers that a 50-foot pole is securely bolted and strapped by ¼x5 inch band irons so that should the bridge be washed away the pole will stands as long as the pier does.

It was the good fortune of the writer to be at the power house during the first rain storm that occurred after the plant had been placed in operation. The weather had been threatening for a day or two and the rain which all felt would come sooner or later, was awaited with no little interest by those connected with the plant. Its advent was marked by a violent windstorm shortly before one o'clock one morning, and so hard did it blow that the inmates of the cottage were awakened by the shaking of the house and the spiteful beating of the sheet rain against the windows. It was a genuine mountain rainstorm of keen severity, but through it all the lights burned in perfect steadiness and the line circuits were as devoid of interest, electrically speaking, as a barbed wire fence. The test was a severe one and it demonstrated that transmission at 16,700 volts over a line supported on glass insulators and porcelain base iron pins, is not susceptible to interfereance by any natural manifestation of wind or water "short of typhoons and tidal waves," as one of the power house attaches put it.

The experience thus far has been that the line is without distinctive phenomena and so far as the practical operation is concerned, it is identical with any 10,000-volt line. It gives no brush discharge at points, such as from the ends of tie wires, it is silent and, in brief, the one who expects to find an outward evidence of the high potential carried will be disappointed in his search for it.

At the Power House.

A seemingly interminably succession of road gates beset the traveler along the last portions of the road to the Yuba power house and, in affording barriers in plenty to restrain the roaming proclivities of stock, they prove equally efficacious in impressing upon the young man of the city, who jumps out and opens them, some features of country existence that he might not have observed otherwise. As the monotony of gate-openings is becoming about intolerable, without fore warning one finds himself almost within the grounds about the generating station, when a two minute drive down a hill, a rumble over a short bridge spanning the stream which comes down the ravine from the spillway in the main ditch half a mile above, and one is at the power house. It is a plain unpretentious structure of corrugated iron measuring fifty by thirty feet and finished within in tongued, grooved and beaded pine, oiled and varnished. The first impression of the station, and one which further investigation confirms, is that it is possessed of remarkable compactness, with careful regard to attain perfect ease of manipulation and control.

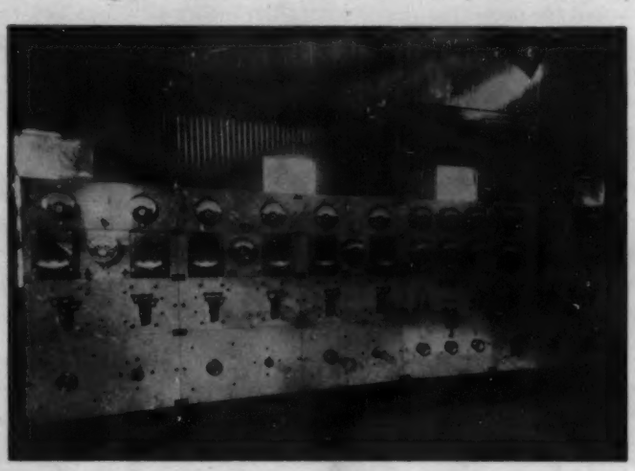


Interior of the Generating Station.

As one enters the station, three 360 kw. Stanley inductor type generators occupy the side of the station at the left, and their respective exciters, each belt driven from its generator shaft, stand in front of the generators. Next to the side wall are three water wheel governors of the relay type, while direct connected to each of the generators through a flexible coupling of four raw-hide links, is the shaft which, after passing through the concrete side wall of the building, carries a 700 hp. Pelton wheel. The hydraulic guage shows a running pressure of 127 lbs. per square inch, and belted from each generator shaft is a tachometer. Along the right hand side of the center of the station for seventeen and one-half feet extends the main switchboard in six panels of blue Vermont marble, placed well out from the side of the building. It is a very handsome board and contains several novel features that will be discussed presently. Across the rear end of the station at a height of eight feet above the main floor is a gallery on which is placed the high tension switchboard. It is separated five feet from the rear wall of the building and contains twelve Martin high tension switches which, as will be shown, form one of the most interesting features of the plant. On the main floor under the right hand half of the gallery are six, 125-kw. Stanley transformers, which take the generator potential of 2400-volts and deliver it to line at 16,700 volts through the Martin high tension switches. Overhead are the banks of Stanley lightning arresters with choke coils, and in a corner where its chains will be incapable of doing harm, is a ten ton travelling crane. A telephone booth and the usual station accoutrements together with an all-pervading cleanliness, completes the pen picture of the Yuba Power plant.

The site of the power house is about 700 feet above the sea level and is closed in on three sides by mountains, the side to the West being open, affords a charming view down Dry Creek Canyon, past mountain, hill and lowland, on for a background, to the great serrated Marys-

ville Buttes, way out in the Sacramento valley nearly forty miles distant. Just below the power house where the vegetation of ages has enriched the soil and where the creek keeps the ground well irrigated, is the vegetable garden, above which are terraced lawns in which beds of flowers are now being laid. These reach to and around the cottage, a well built nine room house, hard finished,



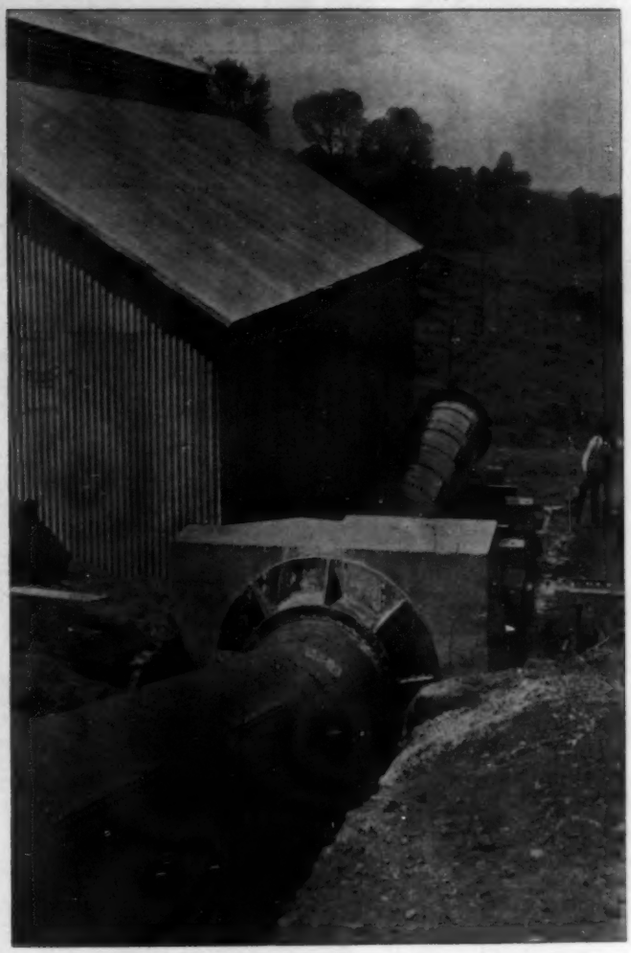
THE MAIN SWITCHBOARD.

containing all modern conveniences and the veranda of which commands to best advantage the superb view just referred to. The mountains confining the power house location are great rolling hills with sides so steep that in places one is apt, if he missteps, to slide on the slippery grass for a rod or so before recovering his footing. The pipe line, main and spillway canals, tail race and cottage are on the northerly hillside; the ravine comes down from the East, while the road winds in through the oak trees on the hill toward the South. It is a walk of about half a mile along the tail race canal around the point of the mountain to the canyon where the inverted siphon is carried over Dry Creek. This forms the scene presented as the initial illustration of this article.

THE ELECTRICAL EQUIPMENT.

The general scheme of arrangement of the hydraulic equipment is shown on the accompanying detailed plan, from which it is seen that each of the 360 kw. generators is direct driven by a two nozzle Pelton water wheel, the generator exciters being driven by belting from the generator shafts. The general arrangement of the interior of the power house has however, been described in the preceding paragraph. "The S. K. C." inductor type generators of the Stanley Electric Manufacturing Company, are by far too well and favorably known to require detailed description, hence it suffices to state that the generators installed in the Yuba Power plant are of the standard form of Stanley inductor machines, operating at 400 revolutions per minute, delivering 360 kw. of energy in two-phase form at a periodicity of 8,000 alternations per minute, at a potential of 1200 or 2400 volts as desired. The generators in question, are coupled up for 2400-volt delivery, and the regulator head cuts in or opposes armature windings so as to give an increase or decrease of the electromotive-force of either phase amounting to ten per cent in ten steps of 1 per cent each. In order to minimize the sometimes pernicious effects resulting from the self-inductive discharge of field windings when operated at 110 volts or higher potentials, the Stanley Electric Manufacturing Company excites the fields at the comparatively low electromotive-force of between 50 and 60 volts. Four pole exciters of the Eddy type and having a capacity of 5 kw. each, at 1350 revolutions per minute, are used, and each exciter is of suffiient capacity for the excitation of any two generators.

Beginning the enumeration at the left, the first three

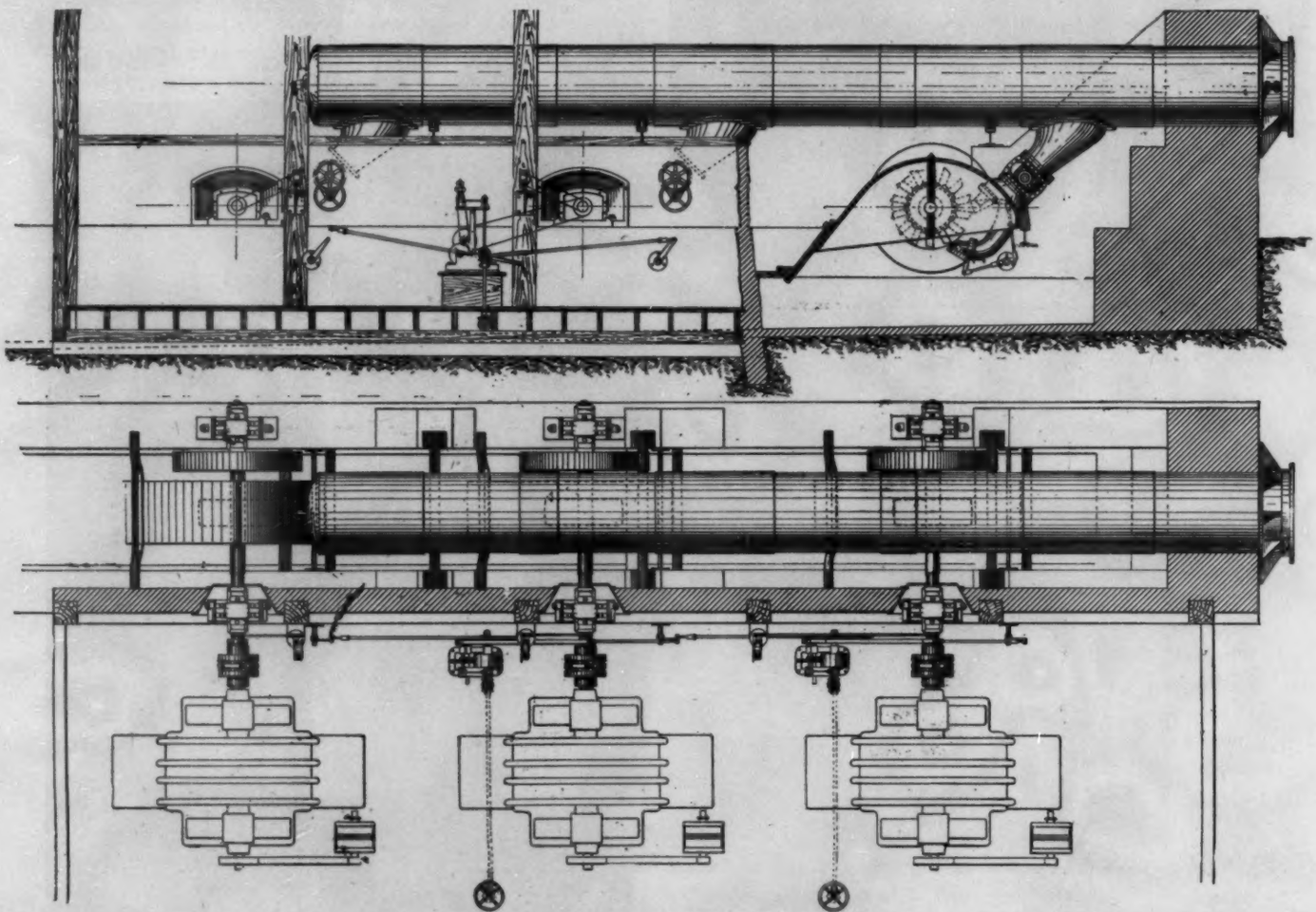


PIPE LINE AND RECEIVER.

panels of the main switchboard are for the three generatars rspectively; the fourth panel is the exciter panel, while the fifth and sixth panels are for the control of the step-up transformers. Each of these panels has a width of 36 inches, and each consists of four sections. In the generator panels, the upper section carries, in addition to a 52-volt pilot lamp, two, circular type, 100-ampere, dead beat ammeters; these are a new form of hot wire ammeter just brought out by the Stanley company and are remarkably dead beat as well as accurate. The second

section of each generator panel carries a Weston direct current ammeter, having a range from 0 to 50 amperes for the field circuit; two, 100-volt incandescent lamps, with key sockets for synchronizing purposes with the other generators, and two static voltmeters having a range of from 1400 to 3200 volts, one being used for each phase. These static voltmeters, which were recently brought out by the Stanley company, and are of a new type as well, are placed directly across the generator terminals. The third section of the panel carries two double pole, double throw switches of the standard Stanley enclosed break type, illustrated herewith, and so arranged as to throw the phases on to either of two sets of bus-bars of four wires each, which run along the back of the entire length of the switchboard. The switch to the left, controls the leading phase and that to the right controls the lagging phase. The illustration of the switchboard shows all switches to be in the upward position, hence both phases of the three generators are thrown in parallel on the upper set of four bus-bars. The fourth and bottom section carries the field rheostat at the left and a double-pole field switch at the right.

The exciter panel presents no deviations from the regular form. The three vertical rows of instruments and appliances ae for the three exciters respectively. The upper section of the panel carries three 0- to 100-ampere Weston ammeters; the second section carries three 0 to 75-volt Weston volt meters, immediately below each of which is a 52-volt pilot lamp. The third section carries three 150-ampere, double-pole knife switches for throwing the exciters in or out of circuit with a single common exciter bus-bar; while the fourth section carries the three handles for the three field rheostats. Contrary to a common practice, no incandescent service is rendered from the exciters, the output of which is used for excitation purposes alone.



DETAILED PLAN OF HYDRAULIC EQUIPMENT.

The remaining two panels of the switchboard are for the handling and control of the primaries of the step-up transformers exclusively, each panel controlling two of the 125 kw. raising transformers. The upper two sections of the two panels carry eight alternating current ammeters, each having a capacity from 0 to 75 amperes, and the lower two sections of the two panels carry eight Stanley double-pole, double-throw switches of the type described. Each of these switches controls the primary of a single transformer, enabling it to be cut in on either the upper or lower set of bus-bars as desired. As but six transformers are installed, one set of switches and ammeters is not in use at present.

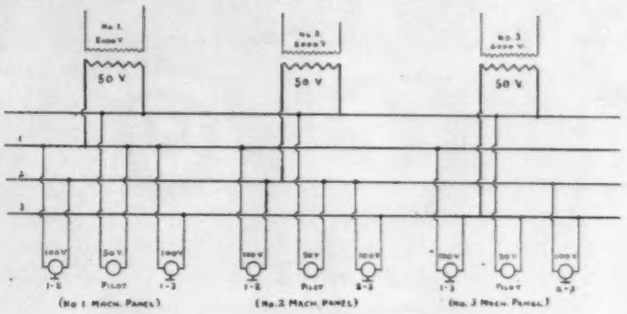
The synchronizing connections are shown in the dia-

gram given and synchronism is indicated by the lamp being out. The process of synchronizing consists of bringing the generator up to normal speed and voltage. When the synchronizing lamp indicates synchronism the generator switch is closed, thus connecting the generators in multiple. After the generators are connected to the same set of bus bars, the individual volmeters no longer indicate the voltage on each generator, but the resultant voltage delivered to the bus bars. In order to determine the proper excitation to prevent an exchange of armature current, the ammeters in the exciting current circuit of each machine is used and the exciting current adjusted in accordance with the load carried.

The lighting arresters are of the new type recently brought out by the Stanley Electric Manufacturing Company, and are arranged as shown in the diagram. Three choke coils are placed in series with each wire of the circuit. These choke coils offer impedance to the high periodicity current of the lightning discharge and at the same time add no self-induction to the line.

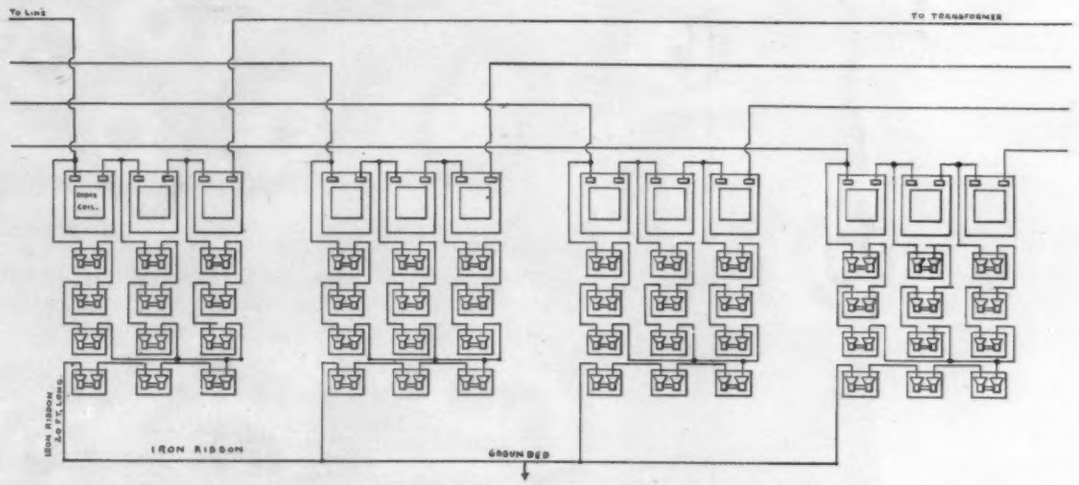
The connections from line to arresters is No. 6 copper wire but the ground connection from each bank of arresters consists of iron ribbon of about twenty feet in length. This arrangement was selected on account of the greater conductivity of iron ribbon for static charges and at the same time introducing a certain amount or resistance between the two wires of a circuit in case of a short circuit resulting from a discharge from both wires at the same time.

All leads to and from generators and exciters as well as to the step-up transformers are carried in ducts beneath the floor. The switch board is as stated, of blue Vermont marble supported on angle iron frames, and carrying in the rear a wooden skeleton on which are run the two sets of bus-bars, the synchronizing wires and the generator and transformer leads. The front side of the switchboard contains no live high tension circuits, and the board itself is a very handsome one. The practice of placing a direct current ammeter on each generator panel for the purpose of giving a direct reading of the field amperage is an innovation in Stanley plants on the Pacific Coast, while the presence of the new and exceedingly valuable types of Stanley dead beat ammeters and static voltmeters, is a further novelty.



THE SYNCHRONIZING CIRCUITS

The six, 125 kw. step-up transformers, which take the generator potential of 2400 volts and transform it to 16,700 volts for transmission purposes, are of the static type, and are incased in boiler iron jackets, having a height of 72 inhes and diameter of 32 inches. The transformer core consists of L-stampings with broken joints which are placed around one side of each of the elliptical coils that extend along the length of the transformer. These two coils each contain both primary and secondary windings and are placed back to back, hence there is but a single core which extends axially in the transformer case. The case is filled with a high grade insulating oil and is water cooled by means of a worm of one-inch galvanized iron pipe closely coiled and placed next to the case and through which a small stream of water constantly flows.

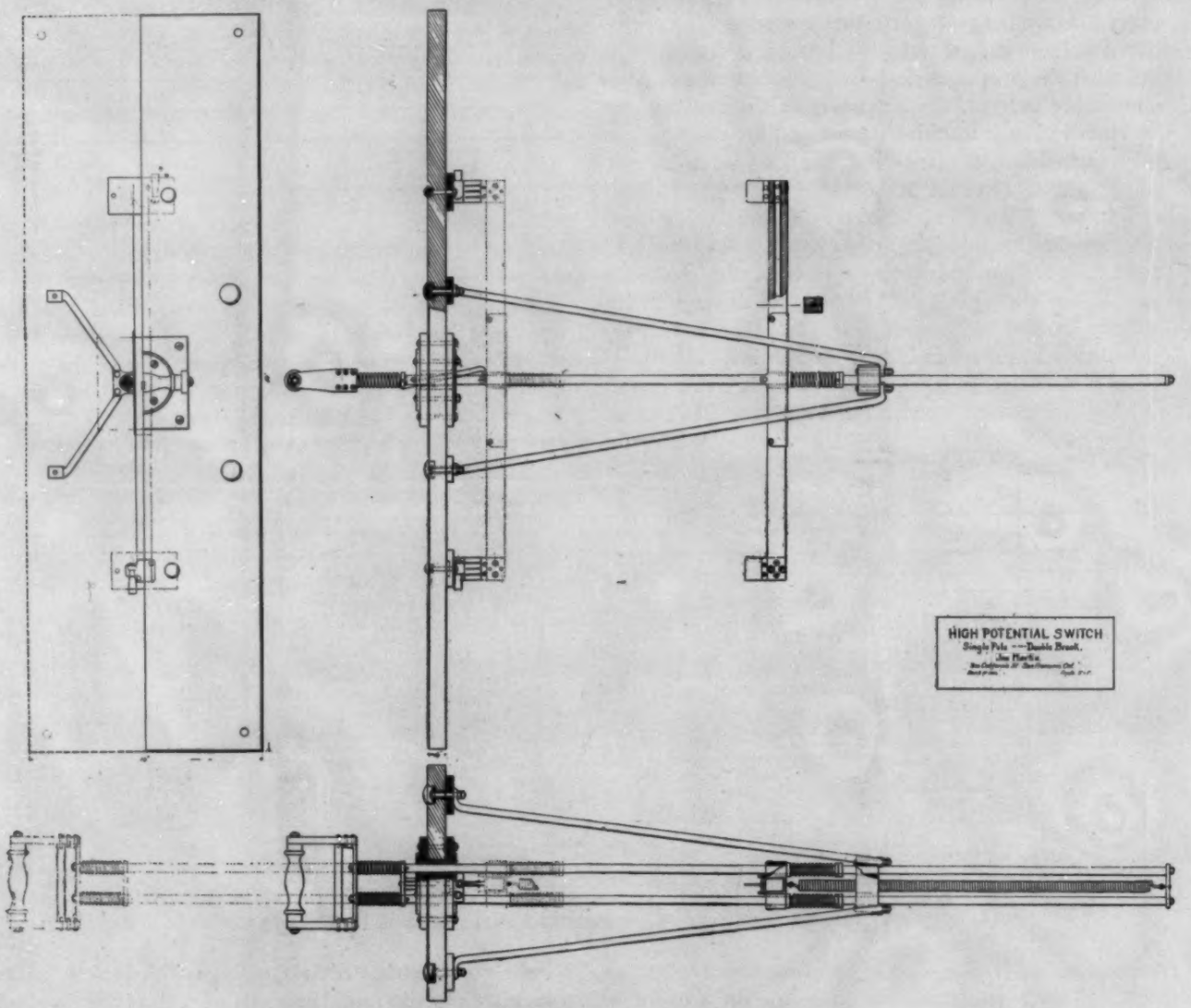


CONNECTIONS OF STANLEY LIGHTNING ARRESTERS FOR 16,700 VOLTS.

The secondary leads of the transformers extend directly up to the rear of the high tension switchboard on the gallery immediately above. The feature of this switchboard is, of course, the high tension quick break switch, full details of which are presented in the accompanying outline drawing. It is a single pole quick action switch, making two breaks of 18-inches each, hence has a 36-

inch break. All portions of the switch on the front of the board are grounded, which eliminates danger from shock. Referring to the drawing below, it will be seen that the switch handle manipulates two parallel rods carrying the movable arm that gives the double break. To increase its rigidity, these parallel rods are supported

Reverting again to the outline drawing, and in particular to the dotted portion of the larger cut, it will be seen that the act of closing the switch by drawing it forward has engaged a projection on the switch bar with a trigger which holds the switch bar rigidly in place until the handle has been pushed forward its full length, when the



DETAILS OF THE MARTIN HIGH TENSION SWITCH.

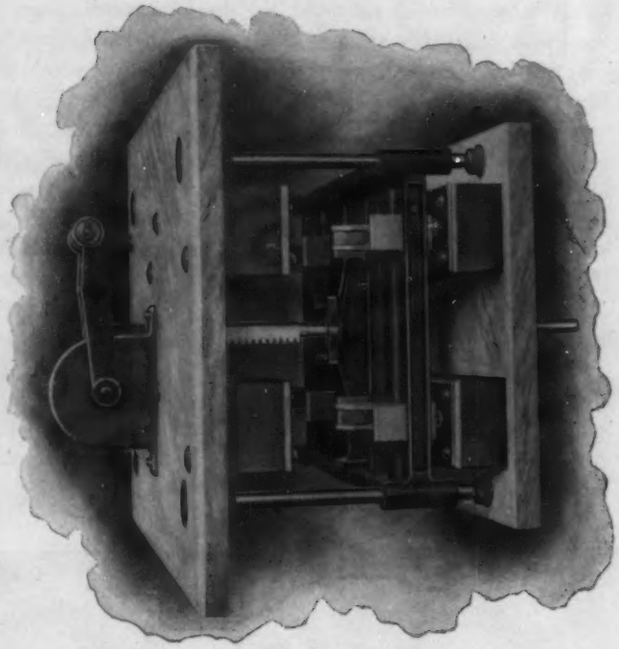
at a distance of 22 inches by angle braces attached to the back of the switchboard, and the act of drawing the switch handle forward closes the circuit by the natural means of pulling the blades of the switch into the clips attached to the back of the board. It is, of course, simplicity itself to close a high tension switch, but the trouble which occurs from the use of such appliances always develops at the instant of opening the circuit. To obviate the difficulties, the Martin high potential switch accomplishes an exceedingly long break—as long as may be desired—in an exceedingly short interval of time. The behavior of this switch in breaking a 30,000-volt circuit is fully described in another article appearing in this issue.

trigger releases the catch and the switch bar is instantly drawn back by the tension of the long spring which was distended during the act of pushing the switch forward. The shock given by the receding switch bar is so thoroughly taken up by spring and rubber bumpers shown on the two parallel rods, that it is practically imperceptible. The stroke of the handle is 20 inches, and the switch extends a distance of 38 inches out from the back of the switchboard; but the space occupied is of no objetion, where the high tension switches are erected on special galleries, as they certainly should be in every instance.

Going Over the Water System.

To examine the water supply of the Yuba Power Com-

pany will consume about two days, when the investigator will have gone over only the most interesting features of it and, in going to the head waters, one does not ride those twenty-eight odd miles from the power house up to

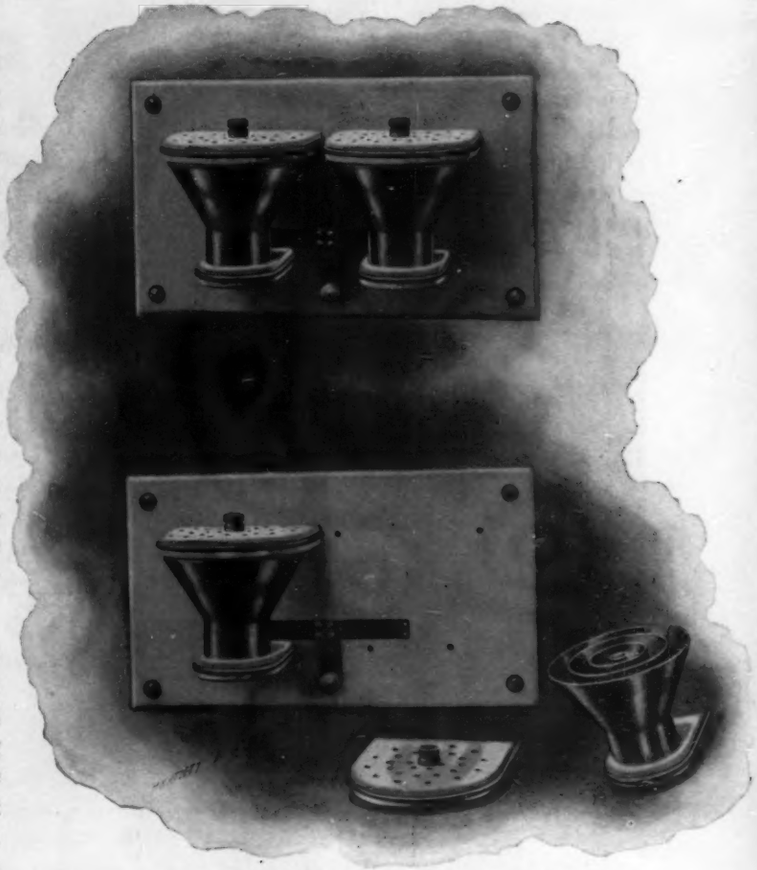


A STANLEY DOUBLE POLE DOUBLE THROW SWITCH.

Dobbin's Ranch without having developed substantial evidences of having been doing something. Among these evidences, the imperative mandates of a ravenous appetite are paramount. We hastened to pledge ourselves to "live in peace forever" by washing in the tin basin and wiping on the roller towel that, in company with a wooden sink, adorn the front entrance of Dobbin's Hotel and, the semi-ablutions over, mine host Merriman, who rightly named, laughs uproarously at every remark, however staid,—is given no opportunity to make second announcement that supper is ready. We were very hungry for we had undergone, or rather overgone, momentous expeiences along tedious roads where the conveyance throws you up in the air, drops you, then meets you half way in abrupt unceremony; we had, in pharaphased electrical parlance, been over a long distance, high joltage line and, once seated at the table, we quickly encompassed every feature presented in the interesting "transmission" then under consideration.

Dobbin's Ranch is but a very little place well up amid the pines of Yuba County and one would soon forget it, with its handful of houses, its rural sleepy ways, and its frogs' chorus at eventide, were it not that, in sitting around the stove in the country store that bears the Dickensonian name of "Slingsby & Gettens" you meet and listen to the experiences of Daniel Gettens, whose marvellous memory, ready wit and relation of stirring experiences of the days of '49, hold you in bonds of deepest interest until long after the time when one should have retired in prepration for the early start on the morrow. Nevertheless, we were up betimes and away shortly after day break on the five mile drive to the little saw mill at the top of the mountain over the river canyon, the nearest point that the wagon road approaches to the upper end of the flume.

Speaking personally, I can not say that any particular pleasure was experienced in going down the trail from the saw mill to the flume. The trail literally stood on end, and it was said that its length was a mile,—in my estimation it was very much of a mile indeed. I do not walk for a living, as the guide for that trip has done for years, and it had been my fortune the afternoon before to go with him from the power house to photograph the flume over Indian Creek. I understood it was to be a five mile walk to Indian Creek and I struck out in his footsteps with agility. Mountaineers walk up hill and down dale with the measured, incessant, unrelenting tread of a perpetual metronome. They never stop, they never tire, nor lose their breath, nor get a-thirst, nor take "spells" nor look at landscapes however enchanting. Their sole ambition is to push the world behind them with their feet until the desired spot on the earth has been at last brought to them. My guide was of this ilk. We went up and over and down six big mountains in his merciless metronomic way before we reached Indian Creek, where I hustled around and took the photographs



THE STANLEY LIGHTNING ARRESTER.

while he sat on the flume,—except during the moment of picture taking. Then we started back at once on the same gait, but not until after I had held him long enough to remark that we had gone a long way, it seemed to me, for one half of a five mile walk. "Five miles each way," quoth he, speeding onward. But as we neared the power house, my aching, quaking knees gave out and, in coming down from the head of the pipe line, I was glad

THE DAM AND HEADWORKS.

the slope was steep enough so that I could ape "Kelly" of vernacular fame, and "slide". On reaching the power house in a state verging on collapse, explanations followed and I found that the five miles was an "air line" distance and that, soft of muscle as I was, I had walked in mechanical precision almost twenty miles that afternoon over trails so rough and steep as to beggar description.

And so, with aches which large and oft-repeated applications of pain killer had allayed not, my stiffened joints quaked in descending the trail from the saw mill to the flume and I contemplated the prospective absence of an

NEAR THE CONFLUENCE OF THE NORTH AND MIDDLE YUBA RIVERS.

ambulance at the end of the day's trip ten miles away, (so my guide said) with feelings akin to despair. The alpenstock did little good in the descent; I clung desperately to the chapparal and young maple as I tried to lower myself down easily, and finally had about concluded to accept the guide's advice to "grease the ways and slide" again, when we reached the flume, hidden amid the trees and brush. Then was experienced, although with some misgivings as to the outcome, the dubious satisfaction of the knowledge that most of the rest of the walk would be on a level flume which, thank Heaven, would bear some semblance to the sidewalks of a civilized community.

The lumber with which the flume was built was cut by the little saw mill at the head of the trail, whence it was carried down the mountain in a wooden chute, the trip being covered in considerably less than a minute. It is one and a half miles from this point up the flume to the dam, with an equal distance over trails in reaching and leaving the flume, and as the flume is seven miles in length, it requires ten miles of walking to go over it. Here a characteristic of nearly all flumes leaves an indelible memory on the mind of the one who visits these mountain fastnesses only once in a while. The boards constituting the foot walks on the upper portion of the

A MILE BELOW THE DAM.

Yuba flume are new, wide, and very firm, but the further down one goes the narrower they become until eighteen inch boards drop to a width of twelve inches, then to ten inches and down on to eight, six, and even five inches, until one is constrained to believe that if the flume were say fifteen miles in length, the foot boards along its lower end would be but bed-slats, or maybe like whalebones, or even necessitating, perchance, that to go over the flume one should be possessed of the equilibristic qualifications of a tight rope walker.

The principal features of the flume are well brought out in the accompanying half tone engravings. Its upper portion before the North Fork of the Yuba joins the Middle Fork, is especially interesting because of the precipitous canyon sides, the graceful windings of the flume and the wealth of foliage. After leaving the confluence of the two streams the elevation of the flume above the

muddy waters of the Yuba gets constantly higher until an elevation of 800 feet is attained, but nevertheless, the route along the mountain side under the blazing sun grows uninteresting, monotonous and wearisome as the lower end is approached, and when at last the flume tender's cabin, marking the terminus is reached, the unprofessional walker finds himself thoroughly hot, fagged, and quite unprepared for the hard, exasperating climb that confronts him up an almost perpendicular trail over half a mile in length. This done, the conveyance is found awaiting at the top of the mountain, while with it has come thoughtful Dan Gettings with restoratives that cheer, and the trip over the Yuba flume, like the adventurous tenderfoot's physical endurance, is practically at an end.

THE FLUME CROSSING INDIAN CREEK.

The Water System.

The water supply of the Yuba Power Company owes its development to the Wright irrigation law under which the Brown's Valley irrigation district was organized some ten years ago. This irrigation district, which covers an area of about 33,000 acres, was bonded for $140,000 in all, and this amount was expended in the development of the water system, that is now the leased property of the Yuba Power Company for a term of fifty years.

Water for the system is taken from the North Fork of the Yuba river at a point in Yuba county about four miles above its confluence with the Middle Fork of the Yuba river. The minimum flow of the North Yuba river, as the North Fork is called, at the point of diversion, is never less than 16,000 miners inches, all of which is located and controlled by the Yuba Power Company, not only by right of the lease mentioned, but also by right of absolute ownership of over 2000 acres of land upon which the dam, flume, power house and sub-station are erected. Inasmuch as the maximum amount of water required for the operation of the present installation for electric transmission purposes, is about 2300 inches, it is evident that there is no ground for apprehension that the water supply may prove inadequate to satisfy all demands. Moreover, should the demand for power by any chance exceed that which is available under the head at which the present plant is operated, the power house could be moved to a point further up in the mountains, and toward the lower end of the flume where a head of over 800 feet, instead of 300 feet as at present, is available. In this instance water for irrigation purposes would be carried on down the ditch in quantities about equal to its present capacity, while the remaining 12,000 or 14,000 miners inches would be available for power purposes at the high head given.

A substantial crib dam, 30 feet in height and having a width of about 150 feet, is thrown across the narrow gorge of the North Fork at the point indicated and as appears, in the illustration on page 154.

At times the river becomes torrential, but any danger of the washing away of the flume intake is averted

through the particularly advantageous location of two great rocks between which the diversion of water to the flume is made. There is practically but one flume in the system and this is the main flume which extends a distance of not quite eight miles down the side of the canyon from the dam as appears in the accompanying engravings. For a distance of five miles from the diversion the flume has a width of five feet and is three in depth, but when the construction of the flume had progressed thus far, the plan originally adopted by the irrigation district was changed by reducing the width of the flume to four feet, the depth remaining as before but with increased grade so as to give equal carrying capacity. The ditch proper is 23 miles long, is 5 feet wide on

AFTER CLEARING OUT THE OLD DITCH.

the bottom, nine feet wide on top and is 2½ feet deep. Its fall is 9.6 feet per mile.

Prior to the lease by the Yuba Power Company, the entire system had been permitted to run down, but during the past winter the ditch has been deepened, straightened, and freed from rocks and slides, while the main flume has been so repaired that it is now in the very best of condition. In fact during the recent trip of the writer over it, the flume was found to be the tightest of any yet seen in California power transmission plants. Several short and comparatively unimportant flumes are placed in crossing ravines along the line of the ditch, and the most important of these is that at Indian Creek illustrated on page 155. The Indian Creek flume is built on an arc, which gives it the appearance of sagging so noticeable in the illustration.

The especial value of the Brown's Valley irrigation system for power purposes rests in a 300-foot "drop" or fall which occurs in the ditch at the point where the power house is located. The original plan of the system and as operated for a number of years, consisted in the carrying of the ditch along the side of the mountain forming a southerly border of the precipitous canyon, through which the waters of Dry Creek flow. The elevation at which the ditch appears on the side of the side of the mountain is too great to be available for the canals on the lower land beyond the opposite side of the canyon. The upper ditch, therefore, formerly emptied into a natural ravine along which it flowed for probably half a mile when it was picked up by a lower ditch and conveyed to the side of the canyon across which it was carried by the "inverted siphon", as the pipe line over Dry Creek is called. The "siphon" is such only in name for it is merely a pipe line supported by a suspension bridge and on the sides ofthe canyon to the ditch on the opposite side which is at a slightly lower elevation.

It is this drop of approximately 300 feet that was available for power purposes and which, considering the favorable market that was near by, led to the organization of the Yuba Power Company. The power house is located at the foot of the ravine referred to and the changes effected in the original system consist, first, in extending the old ditch along the mountain side past the ravine to a point where the use of a shorter pipe line for water wheels was made available, and, second, the building of a new ditch to take the water of the tail race to the inverted siphon at a point some 70 feet below the one to which water was delivered to the pipe under the original system,—the reason for this being that the head at which water was formerly delivered to the inverted siphon was greater than necessary, and the saving of which head increased by that much the working head of the water applied to the wheel. Both the ravine and the old lower ditch (which has been superseded by the new tail race) are now used as spillways, and all the water spilled from the main, or upper canal, together with that from the

DIGGING THE DITCH EXTENSION.

tail race, is delivered to the different portions of irrigation system below.

At first glance it appears that the weak point about the water system rests in the absence of a storage reservoir at or near the head of the pipe line. This weakeness however, is apparent rather than real, for the reason that the storage capacity of the 23 miles of ditch is such that

by closing the intake, there can still be delivered to the wheels 2361 miners inches of water for a period of 10 hours. In addition to this, by damming the ditch in various places, some forty in number where spillways are located, an additional storage capacity of 1000 miners inches for six hours in obtained. Moreover, it is not possible for any break to occur that can not be repaired

DRY CREEK CANYON AT THE INVERTED SIPHON.

within six hours, hence the liability of interruption of water supply is neglible.

A further feature affording additional safeguards to the water supply is found in the metallic telephone circuit extending along the ditch and flume. In this system the flume and ditch tenders plug in their portable telephone test sets where at work or while on patrol, means being provided on each alternate pole by use of spring jacks properly protected from the weather.

The Hydraulic Equipment.

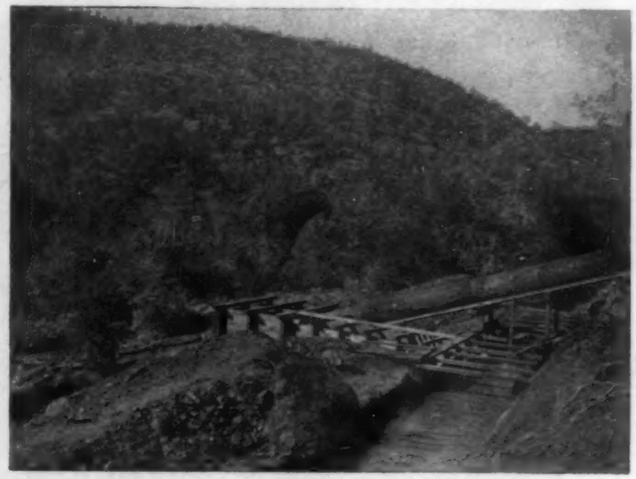
The main ditch terminates in a wooden penstock, measuring ten feet by ten feet by ten feet in depth, whence the pipe line continues in a straight line down the hill side, to the receiver, also in line with the pipe line. The receiver and pipe line have a diameter of 42 inches except in the upper four courses of the pipe line which taper out to a diameter of 54 inches at the point of entrance to the penstock. The pipe is built of steel varying in thickness from one-eighth of an inch to one-quarter of an inch and the pipe was hot riveted, when of numbers 7, 5 and 3 steel, and cold riveted on the remainder. The effective head is 292 feet, and the line which rests on top of the ground and is well anchored throughout

As stated elsewhere, three Pelton wheels are used each being connected by a flexible coupling to its respective generator. These wheels are 40 inches in diameter, and are each supplied with water from two, four inch nozzles. Each wheel had fourteen cast iron buckets, and on each wheel shaft outside the wrought iron housing is placed a 6,000 lb fly wheel. Self oiling and self aligning bearings are used throughout and the wheels are driven at a speed of 400 revolutions per minute. Regulation is effected by the use of deflecting hoods.

A peculiar feature of the hydraulic plant, is the fact that the capacity of each wheel under the head available, is 700 horse-power, while the generators have a rated capacity of but 480 horse-power. The reason for this is a logical one; the generators have an aggregate rated capacity of 1440 horse-power, which marks the normal capacity of the plant; under ordinary conditions however, it is not advisable to load a plant to the full capacity of its generating units without a reserve in the plant for emergencies, but in the Yuba plant it is perfectly safe to load the three generating sets to their rated capacity as in event one set is disabled, the two sets remaining which can be overloaded 50 per cent will prove adequate to carry the load of three generators, because of the fact that the water wheels each have a capacity of 700 horse-power. The water must at all times be delivered from the upper ditch to the tail race in order to supply the irrigating system below, hence the saving of water is not a factor.

Personal and Financial.

The conception of the plan of the Yuba Power Company and the realization of the many advantages it possesses for an electric transmission plant that would from the outset prove remunerative and which would form the nucleus of the system that will, in the near future, supply electric service to many prosperous localities within a wide radius, was due conjointly to Messrs. R. R. Colgate and Jno. Martin who have from the outset been the leaders in the project, both in an active and financial sense. Mr. Colgate, in addition to important holdings in a num-



PENSTOCK OF THE INVERTED SIPHON.

ber of electrical interests throughout the West, is manager of the Atlantic branch of the National Lead Company, New York, and Mr. Martin is so well and favorably known as the Pacific Coast Agent for the Stanley Electric Manufacturing Company that he requires no introduction to electricians. These gentlemen together took up the entire bond issue of the Yuba Power Com-

Company, amounting to $230,000, beyond which there is no outstanding indebtedness.

The Yuba Power Company is capitalized at $300,000, of which all is subscribed by Messrs. R. R. Colgate, W. Frank Pierce, W. M. Pierson, E. J. de Sabla Jr., and Jno. Martin, who constitute the Board of Directors. The officers of the Company are: Jno. Martin, president and general manager; E. J. de Sabla, Jr., vice president; and John Williams, secretary.

The power house, pipe line and pole line were located and surveyed by Mr. Jason R. Meek, C. E., county surveyor of Yuba County. The general arrangement and execution of engineering design of the power house, pole line and sub station was under the direction of Mr. Theo. E. Theberath, chief electrician for Jno. Martin, and who was ably assisted by Mr. F. V. T. Lee, Mr. Martin's assistant electrician, and Mr. Frank Vannata, chief electrician of the Yuba Power Company. The commercial features of the system are handled by Captain J. F. Luttrell, local manager for the Company at Marysville, and the clerical department is in the hands of Mr. H. S. Battle. The sub-station and distribution is being operated under the direction of Mr. George W. Dietz, who executed the contract for the building of the pole line. The flume and ditch is patrolled by six men under the superintendency of Mr. Charles L. Armstrong, who is one of the most capable men in this capacity to be found in California.

There are but few electric transmission plants that have been able to start in operation with a contracted load amounting to over sixty-eight per cent. of the capacity of the generating plant, as is the record of the Yuba Power Company, and this load consists of 300 horse power for the Pennsylvania and Webb mines, in Brown's Valley; 225 h. p. in the Buckeye Flour Mill of the Sperry Flour Company at Marysville, besides numerous other small power installations. The Company has also secured the municipal contract for the arc lighting of Marysville during the next fiscal year, for which service an induction motor and arc dynamo set, probably direct connected, is soon to be installed in the sub-station. Its capacity will be about 60 2,000 c. p. lamps, or say, 50 h. p. Moreover, the Company is now operating about 3,000 16 c. p. incandescent lamps and has approximately 2,000 lamps more under contract which it is installing as rapidly as possible.

Distribution is effected through two sub-stations as intimated heretofore, the principal one being the Marysville sub-station, which is an exact counterpart of the power house as to material and type of construction, finish, and size. It is located on the East side of the city near the levee and contains four step-down transformers, each having a capacity of 125 kilowatts and being practical counterparts of the transformers at the power house. They deliver nominally 2,000 volts to the local distribution, which is further reduced to 110 volts for incandescent lighting purposes by means of Stanley type "G" transformers on the two-phase system. The distinctive feature of these sub-station transformers is the fact that they are each provided with a regulator head by means of which the secondary voltage may be raised or lowered as desired by ten per cent., in ten steps of one per cent each. They are water cooled, the water for which is obtained in the Marysville sub-station, from an artesian well by an electrically driven pump. At present there is no regular attendant at the Marysville sub-station, nor will there be necessity for one until the motor-generator arc lighting set is installed for fulfilling the street lighting contract with the city. All arc lighting now operated by the Yuba Power Company is of the constant potential alternating current type.

The substation at Brown's Valley is located at the Webb Mine, in a portion of the engine room, but inasmuch as the mine is soon to be driven by electricity, the steam plant will be abandoned and the equipment will be an all-electric one. This sub-station contains two step-down transformers, similar in every way to those at Marysville, and, like the latter sub-station has a full equipment of switchboard and lightning arrester apparatus.

Among the principal contractors for the installation were Messrs. Schaw, Ingram and Batcher, of Sacramento, who built the pipe line; the Union Lumber Company, which furnished the poles; Mr. Jno. Martin, agent for the Stanley Electric Manufacturing Company and of Fred M. Locke's insulators and line materials; the California Electrical Works, which built the high tension switches under the specifications of Jno. Martin; and the Pelton Water Wheel Company, which installed the water wheels and hydraulic equipment at the power house.

ENGINEERING DATA OF THE YUBA POWER COMPANY'S PLANT.

WATER SYSTEM.

Length of Flume: 7⅞ miles.
Dimensions of Flume: First five miles, width 5-ft., depth 3-ft: remainder, width 4-ft., depth 3-ft., at increased gradient.
Gradient: Average fall of 14-ft. to the mile.
Lumber used: 1,250,000-ft.
Length of Canal: 23 miles.
Dimensions of Canal: Width at bottom, 5-ft; width at top, 9-ft; depth, 2½-ft.
Gradient: Fall of 9.6-ft. to the mile.

PIPE LINE.

Length: 850-ft.
Diameter. 42-in., except upper four courses which taper out to 54-in.
Material: Steel, varying in thickness from ⅛-in., to ¼-in.
Rivited: Hot on Nos. 7, 5 and 3 steel; cold on No. 10.
Receiver: Diameter, 42-in.; lengtht, 50-ft; Material, ¼-in. steel.
Head: 202-ft., effective.

HYDRAULIC EQUIPMENT.

Kind of Water Wheels: Pelton, tangential.
Number of Pelton Wheels: 3.
Diameter of Wheels: 40-in.
Number of Nozzles per Wheel: 2.
Diameter of Nozzles: 4-in.

Number of Buckets per wheel: 14.
Weight of Fly Wheels: 6,000-lbs. each.
Regulation: Relay governors controlling deflecting hoods.
Connections: Direct to generator units through flexible couplings.
Wheels housings: Wrought iron.
Speed: 400 r. p. m.
Capacity: 700-h. p. per wheel.

ELECTRICAL EQUIPMENT.

Type of Generators: Stanley two-phase inductors.
No. of Generators: 3.
Capacity: 360-kw. each.
Generator potential: 2400 volts.
Periodicity: 8,000 p. p. s.
Type of Exciters: Eddy, 4-brush, multipolar.
No. of Exciters: 3.
Capacity of Exciters: 5-kw. each, at 1350 r. p. m., and 60 volts.
Type of Transformers: Stanley static, oil insulated, water cooled.
No. of Transformers: 12, of which 6 are used as raising transformers in Generating Station, 4 as lowering transformers in Marysville sub-station, and 2 as lowering transformers in Brown's Valley sub-station.
Transformer potentials primaries, 2400 volts; secondaries, 16, 700 volts.
Transformer regulation: Special regulator heads on step-down transformers for raising or lowering secondary voltage 10 per cent, in ten steps of 1 per cent, each independent of Generating station.
Capacity of transformers: 125-kw. each.

POPE LINE.

Length of Marysville line: 18¾-miles.
Length of Brown's Valley Line: 7¼-miles.
Length of Poles: 30, 35, and 40-ft., according to location.
Size of Poles: 12 in. to 20 in. at butt; 7 in. to 9 in. at top; round, 12-20 in. 7-9 in.
Material of Poles: Cedar and spruce in equal quantities.
Butts: Tarred, one-sixth of pole length in ground.
Distance between poles: 120-ft., 44 to the mile.
Right of way: 100-ft. wide, cleared.
Guys: Inverted "T" stubs at corners and angles.
Kind of Cross Arms: 4-pin, pine, iron braced and painted with P &. B.
Size of Cross Arms: 3-in. x 4-in. x 5-ft.
Distance between Cross Arm Centers: 18-in.
Distance between Pin Centers: 18-in.
Distance between Power Wires: 18-in.; phases on diagonals.
No. of Power Cross Arms: 2.
No. of Telephone Cross Arms: 1.
Ties: Western Union long tie.
Insulators: Locke, 5½-in., triple petticoat, annealed glass.
Pins: ½-in., steel, with Locke porcelain base.
Size of Power Lines: No. 6, B. & S., medium hard drawn copper.
Size of Telephone Lines: No. 12, B. & S., bi-metallic.
Telephone Line: 5-ft. below lower power line.
Capacity Marysville Line: 750-kw., ten per cent line loss.

Personal

Lieut. W. Stuart-Smith, U. S. N., has been called from the retired list to active service in the Navy and has reported for duty in the steam engineering department at Mare Island Navy Yard.

Mr. Leon W. Bly, late chief of the testing department of the Wagner Electric Manufacturing Company, but more recently of the engineering corps of the Telluride Power Transmission Company in the installation of the Provo-Mercur transmission, is in San Francisco and hopes to locate here.

Mr. James T. Stockdale has received a well deserved promotion from the position of assistant engineer of the San Francisco office of the General Electric Company, to the Power and Mining Department of the same company at the Schenectady Works. Mr. Stockdale's host of friends in California, in congratulating him on his advancement, will deeply regret his going away.

Miscellany

THE THIRD RAIL SYSTEM IN A SNOWSTORM.

The great snowstorm of January 31st last, which raged over New England, has proved that a railroad can be operated by the third rail electric system under the most adverse conditions. That portion of the New York, New Haven & Hartford Railroad, between New Britain and Hartford, operated by electricity, was kept open during the whole of that day and the trains were run with but few seconds delay in the schedule; while the steam trains on the main lines were held up and delayed for three or four hours.

A heavy snow storm had long been desired by the electrical engineers and railroad officials in order that as severe a test as possible might be applied to the third rail system. It has been a question whether, with the third rail practically surrounded by snow and moisture, the electricity would remain on the rail in sufficient quantity to furnish the necessary current to the motors on the cars. This question was settled by the snow storm. There was absolutely no leakage and once the heaviest part of the snowfall was removed by the snow plows, no interruption in the motor car service occurred.

ALASKA AS IT IS.

Although the public is about sated with Klondyke literature of the kind that appears in the daily press, it still is anxious to get reports that bear the imprint of genuineness and reliability,—something that savors neither of the "paddings" of the sensational press nor of the flaming verbosity of the writers in pay of transportation companies. A disinterested and reliable statement of fact is desired above all else, and when this fact is from the pen of a well known traveler and lecturer whose honesty of purpose is established, it is of treble value.

"Alaska, its waters, land and life," is a pamphlet that fills these requirements and throughout one is interested in the graphic descriptions of the truly wonderful region which is the Mecca of thousands of gold seekers. The author, Mr. John E. Bennett, takes the traveler from San Francisco through Juneau and past the glaciers clear on to Unga and Unalaska, then by the High Kotusks and the waters of the Lewis Yukon, as well as along the Dyea river, the Chilcoot Pass and Lakes Lindeman and Bennett and the White Horse rapids, to Dawson. The gold placers of the Klonkyke creeks are fully discussed, with all the deliberation of a sage observer of wide experience. It is by no means that gold forms the only richness of the Arctic region under consideration for specific reference is made to manifold other valuable resources, of particular interest being mountains of iron ore and a great lake of petroleum These and many other interesting features are well pictured in the profusely illustrated pamphlet which is bound to prove enjoyable and profitable reading to all.

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EDITORIAL.

AN ELECTRICAL REGIMENT.

Marked recognition is given to the active part that electricity plays in modern warfare by the action of the Secretary of War in calling upon Captain Eugene Griffin, second vice prisident of the General Electric Company and a graduate of West Point, to raise a regiment or brigade of engineers to be comprised of civil, mechanical and electrical engineers, practical electricians, mechanics, draughtsmen and men familiar with all kinds of engineering work. There is a bill now before Congress, already passed by the Senate, for the expansion of this proposed regiment into a brigade, and those possessing proper qualifications in the directions indicated and as are desirious of enlisting can do so by making application to Dr. Thomas Addison, manager of the San Francisco office of the General Electric Company, in the eleventh floor of the Claus Spreckels building.

Applications may be made in writing and in every instance, information must be given concerning the following points: First, name; second, address; third, age; fourth, married or single; fifth, where born; sixth, professional experience; seventh, military experience; eighth, does the aplicant speak Spanish; ninth, experience in the tropics.

The making of application in the manner above indicated will simply signify to Captain Griffin that the applicant has an intention or desire to enlist in the engineering brigade when the proper time comes. No more worthy cause could be conceived and the call should meet with such a response that, in attesting the patriotism of the electrical industry, will enable the Government to enlist the services of the very best talent in the profession in its electrical regiment.

ELECTRICITY ON A MODERN WARSHIP.

Some surprising data appear in an article under the accompanying caption in the current issue of "The Engineering Magazine" under the authorship of Mr. George H. Shepard, which first points out the almost incredibile inefficiency of the steam engines used as naval auxiliaries, then discusses the possible uses, defects, efficiency and proportions of an electric plant that would be required to supplant steam for the direct operation of naval auxiliaries, and finally reaches a conclusion that from the reasoning given, the limit to the application of electricity to the auxiliary needs of a modern warship depends upon the future improvements in electrical appliances, especially in the matter of weight.

While the inefficiency of small steam engines, and notably that of duplex pumps, is notorious, one is not prepared for the statement that there are engines in use in the best war ships that are using from 100 to over 300 pounds of steam per indicated horse power, while an average of thirty one of the engines indicated on the "Minneapolis" showed an average of 119 pounds per i. h. p. "In other words," observes the writer, "The data show that at 8 pounds of water evaporated per pound of coal, 5,769 pounds of coal can be saved per hour." Further on, in discussing the increased efficiency that would result from the furnishing of electric power to all the auxiliaries of the "Minneapolis," Mr. Shepard states that "at this rate, the saving to the Minneapolis would be about seventy-five dollars per day in port, and somewhat more at sea," which is assumed to be the average value of the 24,000 pounds of coal that the electric plant would save daily.

It appears from the article that for a first-rate protected cruiser about 1600 i. h. p. would b allowed for the auxiliaries, and for a heavy battleship, about 2,400 i. h. p.; but with an assumed load factor of fifty per cent., an electric power plant for the auxiliaries of a battleship must consist of at least 1,200 i. h. p., requiring dynamos that, with an efficiency of 82 per cent. for engine and dynamo, and 88 per cent for motors, will be capable of developing 1,014 kilowatts. Under present naval regulations the potential is restricted to 80 volts and it is impracticable to install generators having a current capacity in excess of 1,000 amperes for a dynamo, hence it would require thirteen dynamos to give the necessary power at 80 volts. It is impossible to find room on a battleship for thirteen such dynamos. Should the regulations be modified so as to permit the use of 220 volts, it might be possible to find room to install the five dynamos required, together with the sixth generator set that is required to bring the reserve up to the required 30 per cent. These six genera-

tors, which must be direct connected to independent engines will weigh 524,000 pounds if operated by simple engines, or 440,000 pounds if operated by compound engines; the weight of motors required to supply the 2,400 horse power for all the auxiliaries would be 241,650 pounds, making the weight of engines, dynamos and motors 681,650 pounds, which is almost exactly three times that of the present steam system.

Electricity then possesses every advantage as to efficiency, economy, and desirability for supplanting steam in the operation of naval auxiliaries, but despite these advantages, which are almost universal paramount, its use in this direction is impracticable at present simply because it requires the weight of the auxiliaries to be multiplied by three. The force of this argument will be understood when the fact is appreciated that war ship design is a constant struggle to save weight in order that the war vessel, on a given displacement, may have the speed, protection and offensive power to enable her to meet and conquer any vessel of her class; and therewith, the more coal endurance the better.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

MEASURING THREE PHASE CURRENTS.

The Hanover Polytechnikum has adopted a method of measuring three phase currents that is simple and economical of instruments and of time required. It is moreover, applicable to both the star and delta systems. Indicating the three wires by the letters A, B and C, the power in both systems in equal to the voltage between A and B multiplied by the current in C, plus voltage between A and B multiplied by the current in B.

An illustrated description of the method appears in the London Electrical Review for December 10th, 1897, in which is diagramatically shown the arrangement of a switchboard with permanent connections for making these readings with ease and facility.

COAL AT FIVE CENTS A POUND.

The Consolidation Coal Company, whose mines are on the Baltimore and Ohio Railroad near Cumberland, Md., ship considerable coal to San Francisco for smithing purposes, and the cost of the coal at the mines and the price at which it is sold to consumers in certain parts of California has developed an interesting situation with reference to transportation charges.

The company gets 85 cents a ton for the coal at the mines, and then it is sent over the B. and O. to Locust Point, where it is loaded on vessels and goes around the Horn to San Francisco. From there it is shipped by rail to the interior points and then placed in sacks and carried on mules to the small mining settlements scattered through the mountains. This coal is retailed in these settlements, in some of which being hundreds of miles from the railroad, it sells at 5 cents a pound, or at the rate of $100 a ton.

SAND POWER FOR MINING PURPOSES.

Mr. L. B. Andrews recently discovered some rich stringers of gold bearing quartz between Death Valley and Shadow Mountain, in San Bernardino county, Cal., but being far out in the desert, he was, for a time, nonplussed as to means for milling and marketing the ore. Considering the distance to railroad transportation, he deemed it out of the question to ship his ore at a profit. Wood and timber there were none, and only sufficient water for camp purposes and an arrastra. No feed in sufficient quantity for animals was to be had, and it began to look as though Mr. Andrews would be forced to abandon his find.

"I was about to pull up stakes and break camp," said he, "when an idea struck me, and I determined to carry it out. The section in which I am located is particularly sandy, and the wind blows at times with great velocity. I thought that a means could be devised for utilizing both. To think was to act, and I proceeded at once to secure the necessary material for my plant. I first built an immense bin, capable of holding many tons of sand. Below this bin I erected a large overshot wheel, gearing from the wheel to an 8-foot arrastra, which I had constructed. Alongside the sand bin I also erected a windmill, and to this I geared a line of elevator buckets, each bucket capable of holding about ten pounds of dry sand. After I had completed the work, I turned my wind-mill loose. The buckets would take the sand and pump it into the bin; from the bin it found its way to the overshot wheel, and from the wheel I derived abundance of power with which to run my arrastra. I have a calm once in a while, but as my bin is capable of holding a large surplus of sand, so for I have been able to run continuously, with the exception of a few hours, and with proper regulation I do not think I would have lost that time. Had I sufficient water for milling, I am confident that I could keep a 5-stamp mill going with my sand power. I have now had my arrastra working continuously for fifty-two days and nights, and am pleased with my new power. I have not found it necessary to make any repairs, except for the first few hours in starting, and since then everything has worked like clock-work."

Mr. Andrews showed as an evidence of his first work a 42½-ounce gold brick, valued at about $750. He proposes to at once take out letters patent on his new device, as he believes that ere long the power will be in general use throughout all the desert sections.

Transmission

SOME DATA OF A 30,000 VOLT LINE.

SOME interesting experiments with high voltages on the power linese of the Yuba Power Company's Plant, which has just been completed near Marysville, Cal. were made early during the present month. These experiments were conducted by Dr. F. A. C. Perrine and some of his senior students from Stanford University, assisted by Messrs. Theo. E. Theberath of the Stanley Electric Company and Frank Vanatta of the Yuba Power Company.

A description of this Plant will be found elsewhere in this issue, and particular attention is called to that part which deals with the pole line construction. Briefly, the pole line consists of two four wire circuits arranged side by side on the same poles extending from the power house to a junction pole distant about six and one-quarter miles, from which place what is known as the Brown's Valley circuit, extends about three-quarters of a mile further to the Brown's Valley mines, making the total length of the four wire circuit about seven moles. The line is built throughout of No. 6 B. & S. medium hard drawn copper wire, secured with the new Western Union tie to 5½ in Locke annealed glass insulators, which are secured to the cross arm by means of steel pins having locust wood tops and porcelain bases. The pins and cross arms are coated with two coats of P. & B. paint.

For the purposes of the test the wires of each phase were connected in series at Brown's Valley, making a two wire single phase metallic circuit fourteen miles in length and in this way both ends of the circuit were controlled at the power house. The normal initial voltage of this line is 16,700 volts, and for the purpose of the test two transformers having a ratio of 2300 to 16,000 volts were connected in series and used as step up transformers with two other transformers connected in like manner used as step down transformers. All of these being located at the power house.

Some preliminary experiments that were made showed that when an e. m. e. of 30,000 volts was placed on the line, some wires in the Brown's Valley sub-station, which are not more than 2¾ inches apart, would short circuit or arc across, the arc travelling along the wires for some distance until it reached a place where the wires widened out and the arc could no longer maintain. As soon as the arc was broken the line would short circuit as before. This section was then cut out and the connections arranged so that the wires were in no case distant less than eighteen inches from each other. After this had been done the potential was carefully raised to 30,000 volts and held there until reports from observers, who were stationed at intervals along the line, were received. At this time, and under these conditions, the switchboard ammeters showed that the line current was about 2¼ amperes, with the ends of the line open and without the step down transformers being connected in. This current being the charging current of the line but representing little expenditure of energy.

After these observations had been taken the step down transformers were connected to the line and the voltage again raised, the potential reading at the ends of the line being approximately 29,500 and 29,220 volts, under which conditions the line current was 2.08 amperes. Raising the potential to 31,500 volts gave a reading of

THE MARTIN SWITCH BREAKING 30,000 VOLTS.

2.12 amperes which compared with the reading on the open line shows the effect of added self-induction in increasing the line current.

The drop in the voltage observed indicated that the fall of potential over the line was in the neighborhood of 250 volts though the C. R. drop itself would account for only 95 volts, calculated on the basis of the current and resistance of the line, the remaining 185 volts being

chargeable to line inductance and capacity.

No artificial load was applied to the line as it was found that when a voltage of 30,000 volts or more was impressed on the line, a leakage occurred across the back of the high potential switchboard in the power house. This leakage was partly due to the roughened surface of the marble and also to the fact that the board was designed for operation at 16,000 volts. When this leakage occurred it was evidenced by very loud reports; and as the plant at the time of the test was providing light and power service in Marysville, it was not deemed advisable to risk a dangerous short circuit on the station board due to the increase of the load at a potential 30,000 volts.

The "Martin" high potential switch which is used on the high potential side of the transformers at this plant, was thrown at a time when the potential was as high as 30,000 volts. Although the arc was very vicious, (as is shown by the accompanying photograph) it was successfully broken, and the line opened without any difficulty by the aid of the switch. Notwithstanding the nature of this arc, on a close examination of the switch being made, no burning of contacts or other evidences of the powerful arc over three feet in length was developed, demonstrating that the switch could be used, with but slight modifications, for voltages as high or even higher than those used in these experiments.

Voltages as high as 34,000 were read on several occasions and once almost 36,000 volts was impressed upon the line, but no readings of current, etc., were then taken, as it had not been originally proposed or preparations made to experiment with potentials as high as this.

Along the line during the test, no static discharges or illumination of the line were noticed at any time, although careful watch was kept by observers stationed at different points along the pole line. These observers were all equipped with telephones so as to enable them to communicate with the power house at all times. This absence of static discharge and the so-called phosphorescence said to be noticeable on high voltage lines, was remarkable in view of the experience of others and particularly in view of the experience of the Utah plant when a similar test was made.

The experiments demonstrated conclusively the practicability of using voltages much higher than those at present in use or contemplated with but a very slight modification of the line insulation, transformers and generators already on the market.

THE DINGLEY BILL IN HANDY FORM.

The American Protective Tariff League has just issued another and very complete edition of our Tariff laws. This volume of 144 pages, gives the official text of the Dingley Tariff; complete comparison of the Dingley and Wilson law; and, index to all articles covered by the new Tariff. The book will be of great value for reference and for answering all questions regarding the Tariff question. It will be sent to any address for 25 cents. Ask for document No. 27, and address the American Protective Tariff League, 135 West 23d street, New York.

Educational

ALTERNATE CURRENT WORKINGS

By Donald H Fry.

Part iii

THE CALCULATION OF POLYPHASE CIRCUIT FUNCTIONS.

EVERY wire carrying an electric current is surrounded by a magnetic field which varies in strength with the current causing it. Undisturbed by any opposing field the magnetic lines of force pass around the wire in circles, the planes of which are perpendicular to the wire, and the direction of which is the same as the direction of rotation of an ordinary right hand screw when the current is flowing in the direction of the point of the screw. This may be seen in fig. 17, which represents the cross section of a wire and its surrounding field; the current is supposed to be flowing away from the observer. If two wires are run parallel, one carrying a current, the second will be undisturbed by the field of the first so long as the current is constant and its field stationary, but if the current vary, these magnetic circles expand and contract as the current is increased or decreased, and so the second wire is cut by them and consequently an electromotive force is set up in the wire just as though it were moving in a stationary

FIGURE 17.

field. If the second wire carries the return current of the first, the two affect one another and the value of the electromotive force set up is doubled. In an alternating current this induced electromotive force follows 90 deg. behind the current and is the *self-induction* of the line, causing a *reactance* which acts in much the same way as the ohmic resistance of the wire except that the resistance directly opposes the flow of current while the reactance opposes any change or variation in the flow. Thus the resistance and the reactance act at right angles to one another and their resultant is called *impedance*, which is the total opposition to the current; its value is $\sqrt{R^2 + S^2}$ where R is the resistance and S the reactance.

The reactance of a line varies with the size of wire, the

distance between wires, the frequency of the system and also the curve the current follows. The accompanying table of the reactance and impedance of various sized wires is calculated from the equation

$$S=\frac{2\pi f}{10^9}(9.2\ \log\frac{d}{r}+1)l$$

where l is the length of the line in centimeters and $\frac{d}{r}$ the ration of the distance between wires to the radius of the wire. This equation is based on the assumption that the current follows a sine curve; for a saw tcoth or a peaked curve the values would be slightly higher. The frequency 60 is chosen because it is the most common in power-transmissions, but for any other frequency the values may be derived from the accompanying table by multiplying the figures in the reactance column by f/60.

Thus suppose it is desired to find the reactance and impedance of a circuit of No. 2 wire with conductors 18 inches apart and carrying a current alternating at a frequency of 125 alternations per second. At frequency 60, the reactance per mile is 1.260; at frequency 125 it is $1.260\times\frac{125}{60}=2.625$, and the impedance is $\sqrt{(1.662)^2+(2.625)^2}=3.169$ ohms per mile.

GAGUE NO. B. & S. WIRE	RESISTANCE OHMS PER MILE	DISTANCE BETWEEN WIRES IN INCHES	FREQUENCY=60	
			Reactance	Impedance
0000	.521	18	1.119	1.234
		24	1.189	1.298
		28.3	1.228	1.334
000	.657	18	1.148	1.323
		24	1.217	1.383
		28.3	1.257	1.418
00	.829	18	1.176	1.439
		24	1.245	1.496
		28.3	1.285	1.529
0	1.045	18	1.294	1.594
		24	1.272	1.647
		28.3	1.313	1.678
1	1.318	18	1.230	1.803
		24	1.300	1.851
		28.3	1.341	1.883
2	1.662	18	1.260	2.085
		24	1.330	2.129
		28.3	1.369	2.153
3	2.096	18	1.288	2.460
		24	1.360	2.498
		28.3	1.400	2.525
4	2.643	18	1.315	2.952
		24	1.385	2.984
		28.3	1.425	3.003
5	3.332	18	1.344	3.593
		24	1.413	3.619
		28.3	1.454	3.635
6	4.202	18	1.373	4.424
		24	1.441	4.442
		28.3	1.482	4.456
7	5.299	18	1.402	5.481
		24	1.470	5.499
		28.3	1.510	5.510
8	6.682	18	1.428	6.833
		24	1.498	6.848
		28.3	1.538	6.857

If a third wire is parallel to the two wires of an alternating circuit, it will be affected by them both unless it is equally distant from the two, for then the inductive effect of the one neutralizes the inductive effect of the other. This can readily be seen without mathematical proof when it is remembered that the value of the current in all parts of a circuit is identical, but the flow in the two line wires is in opposite directions thus causing opposing fields which will exactly counter balance one another at all points equi-distant from the two wires. If *a b*, figure 18, are the wires of an alternating circuit, a third wire *c* anywhere on the line bisecting the line *a b* and perpendicular to it will have no induced electromotive force set up in it. In a like manner it is seen that if there are two complete circuits *a b* and *c d*, neither will affect the other if the wires of one are equi-distant from the wires of the other, and this is made use of in two phase power transmissions where the wires are run in a square, the phases forming the diagonally opposite corners. The wires of each phase will still affect one another by self-induction,—that cannot be over come—but the disturbing influence of one phase upon the other, or the mutual nduction is eliminated. The mutual induction of a three wire transmission is also overcome by arranging the wires in the corners of an equilatteral triangle.

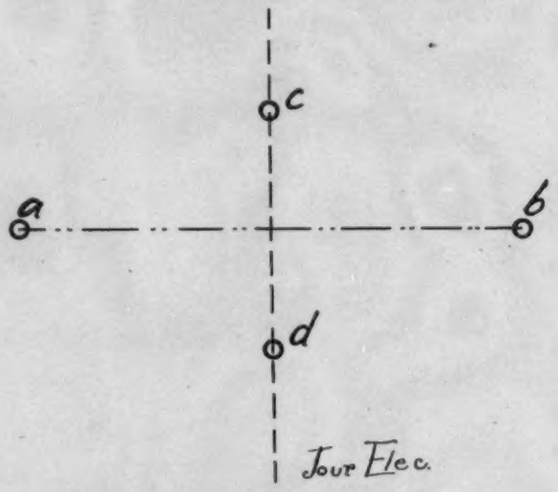


FIGURE 18.

It might be well to explain the calculation of a transmission line and the use of the above table by an example. Assume a 100 kw. two mile transmission employing a two phase system with a frequency of 60. The current is to be delivered at 2,000 volts, and we shall further assume the load to consist of lights only and therefore practically non-inductive. If the load is balanced, each phase will transmit 50 kw. and the current in each phase will be $\frac{50000}{2000}=25$ amperes. Deciding on a line loss of 4 per cent, the loss in watts for one phase will be 2000. As C=25 and $C^2R=2000$, R, the resistance of the line is 3.2 ohms or 1.6 ohms per mile of line. The resistance of No. 2 wire is 1.662 ohms for the mile of double wire, which is close enough. As stated above, to

overcome the mutual induction of the two circuits the wires should be run in a square with the phases forming the diagonals, so if the wires are 20 inches apart there will be 28.3 inches between the wires of a phase, and from the table we get the impedance of No. 2 wire, which is 2.153 ohms per mile or 4,306 ohms in this case. The drop will be $4.306 \times 25 = 108$ volts and so the voltage at the generator must be 2108 volts. In this instance, the ***line loss*** is approximately 4 per cent but the ***line drop*** is nearly $5\frac{1}{2}$ per cent.

When the current lags appreciably, as is almost invariably the case with a motor load, it is not such a simple matter to ascertain the loss and drop in a line, but an approximation can be derived in the following manner. Assume a 1000 kw. 10,000-volt, three phase-power transmission, the length of the line to be ten miles and the frequency employed 60. The power factor of the load, which is to consist of motors and lights combined we shall assume to be 90 per cent. Furthermore we are to step up from the machines to the line at a ratio of 1 to 5 and step down again at the sub-station at the further end of the line at 5 to 1, the pressure at the secondary terminals of the step down transformers to be 2000 volts. We may further assume a copper loss of 1 per cent, a hysteresis loss of 1 per cent and a magnetizing current of 4 per cent in both step up and step down transformers. Deciding the total loss in the transmission is to be 10 per cent with the assumption that the loss in both sets of transformers is 4 per cent (the magnetizing current is 90 degree ahead of the secondary voltage and is therefore entirely wattless) this will leave 6 per cent for the line loss. The current in the step-down secondary, or the load current is, with a power factor of 90 per cent $\frac{1}{3} \times \frac{1000\,000}{2000 \times .9} = 185.2$ amperes per phase, and this would give, neglecting magnetizing current and all losses, $\frac{185.2}{5} = 37.04$ amperes per phase in the line. To this we must add 1 per cent to make up for the iron or hysteresis losses of the transformer, and also account for the 4 per cent magnetizing current.

Let *OE*, figure 19, represent the secondary voltage, and *OC* the current lagging behind by the angle φ. In this case cos φ, the power factor is .9. At right angles to *OE* draw *OA*, in length .04 times *OC*; this is the magnetizing current multiplied by the ratio of transformation, and in phase is 90 deg. ahead of *OE*. The length *CA*, the resultant of *OC* and *OA*, is 1.018 times *OC*, sa the current in the line will be $37.04 \times 1.01 \times 1.018 = 38.08$ amperes. To derive the current and the generator voltage, we must again multiply the line current 38 08 by 1.01 and by 1.018 and this product by 5, the step-up ratio, which gives 195.7 amperes as the curent per phase. As each wire of the line carries the current of two phases 120 degrees apart, the current in the wires will be $38.08 \times \sqrt{3} = 65.9$ amperes. Since the C^2R loss in the line is to be 6 per cent, the loss in each wire will be 2 per cent or 20,000 watts, and as C is 65.9, *R*, the resistance of each wire will be 4.6 ohms or .46 ohms per mile. Our choice of wire then lies between No. 00 and No. 0. Deciding on No. 0, as that is nearest, gives the resistance drop of the line of 10 miles of double wire to be $65.9 \times 10.45 = 688$ volts. The reactance of the line, if we space the wires 24 inches apart will be 12.72 ohms. Only the current in one phase causes a reactive drop so this is derived by multiplying 38.08 by 12.72 which gives 484 volts. In ascertaining the action or effective voltage of the load from the current, that part of the current which is used to make up the iron losses must not be included. The value of the current will be $37.04 \times 1.018 \times 1.018 = 38.37$ amperes, and as each phase is to transmit 333333 watts the effective volts will be $\frac{333333}{38.37} = 8687$. The reactive voltage due to the inductance of the load and the transformers will be $\sqrt{\{(10000)^2 - (8687)^2\}} = 4953$ volts. The copper or C^2R loss in both transformers is 2 per cent of the work of one phase or 6667 watts. This is made up of the primary and secondary and leakage losses of both step-up and step-down transformers, but as it merely causes a drop in the secondaries, we may roughly count C the line current which will give the effective volts drop 175. The total effective volts will be $8687 + 688 + 175 = 9550$ and the total reactive volts or wattless volts $= 4953 + 484 = 5437$. The total volts impressed at the generator will be $1.5 \sqrt{\{(9550)^2 + (5437)^2\}} = \frac{10990}{5} = 2198$ volts. The power factor of the total transmission is equal to the effective

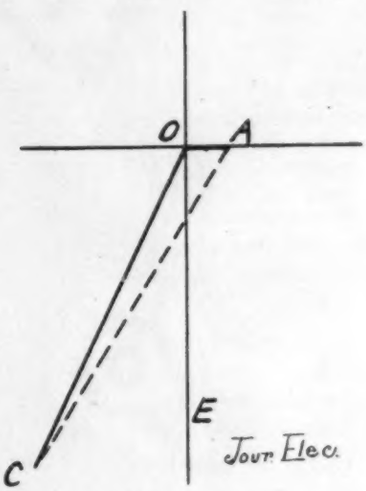


FIGURE 18.

volts divided by the total impressed volts, which gives in this case 86.9 per cent. The total volt-amperes at the generator is $2198 \times 195.7 = 430,150$. The watts are obtained by multiplying the volt-amperes by the power factor or $430150 \times .869 = 373800$ watts. The efficiency of the total transmission is $\frac{333\,333}{373800} = .892$ or .89.2 per cent.

The ***capacity***, or condenser effect of the line is still to be considered. Every alternating circuit is more or less affected by the capacity of its line wires tending to give the current a lead over its electro-motive force, but where the voltage is not very high, this may safely be neglected.

The capacity cannot be determined exactly beforehand, for although a very close approximation can be obtained from a formula given by Steinmetz, of the General Electric Company, when the length of line, the size of wire and the distance between wires is known, still there are other factors in the problem such as the climatic conditions, height from the ground, and atmospheric pressure; and also, the form of the current wave makes a difference. If K denote the capacity in microfarads; l, the length of transmission in miles; and d/r the ratio of the distance between wires to the radius of the wire, the formula is $K=\frac{.0192\ l}{\log.\left(\frac{d}{r}\right)}$ This will give the capacity of the line to be .0885 microfarad and from the formula $c=2\pi f E K$, the charging current c is found to be 0.3 amperes. This would slightly reduce the value of the current and increase the power factor, but is too small to affect the efficiency of the transmission appreciably.

One of the larger electrical manufacturing companies recently published a phamphlet on "Alternating Current Machinery"—a reprint of a series of articles that appeared in an eastern electrical publication in 1896. It is an estimable article and well written, but there is certainly room for criticism of the manner in which the writer (he does not sign his name) calculates a transmission line. Purposely the figures in the above approximation were taken the same as his in order to compare results, and it is a wonder the discrepency between the two is not even larger.

In the first place his line is to be a 10,000 volt three-phase transmission, yet the phamphlet states that "the difference of potential between any two conductors will be $\frac{10000}{\sqrt{3}}=5{,}775$ volts." Why? In speaking of a 10,000-volt transmission it is usually meant that the difference of potential between the two wires is 10,000 volts, but suppose it is the transformers that give 10,000 volts? Then if they are connected Δ the difference between the line wires is 10,000 volts, while if they are connected Y^2 the difference would be $10{,}000\times\sqrt{3}=17{,}320$ volts.

But in the next move the author gets on his feet again. "Consequently." he goes on to say, "the energy current for each phase, that is, in each conductor, will be 53 amperes, since each phase is to supply 333 kw." Now unless the transformers are connected Y, the current in each phase and the current in each conductor are not the same, for each conductor carries the current of the two phases to which it is connected and as these currents are 120 deg. apart the total current in each wire is $\sqrt{3}$ times the phase current. To correct one mistake by another is hardly legitimate, yet by this means he derives an approximate value for the current and so gets the right sized wire, No. 0.

Further, the writer referred to goes on to state that "the reactance of No. 0 wire at 60 cycles per second is seven-tenths of an ohm per mile, or seven ohms in this particular case." Aside from the fact that .7 is rather a low estimate for the reactance, it might well be objected that the reactance of a certain sized wire has not a fixed and definite value, for the distance between the wires has as much to do with the reactance as the size of the wire. To illustrate this, the reactance of No. 3 wire, 18 inches apart, is the same as that of No. 00 28.3 inches apart, or the reactance of No. 8 wires run 10 inches apart is approximately the same as No. 0 at 24 inches. In order to derive the reactive drop he multiplies the reactance, 7 ohms, by the value of the total current in the conductor when the reaction of self-induction can only be due to the current in one phase, but his low estimate of the line reactance again counterbalances the mistake, and so he goes serenely on and after calculating the apparent efficiency and calling it the power-factor, he tackles capacity and the effect of harmonics, subjects that will hardly stand treating on "the percentage method." In fact with the exception of the first error most of his mistakes are mainly due to treating all losses as percentage losses, a method which is very confusing and at best unsatisfactory.

Any attempt to entirely eliminate mathematics from alternating currents must necessarily result in failure. Reasoning *a priori* is not permissible, and to solve problems without the aid of at least the elements of mathmatics is an inherent impossibility.

"Congratulations on the pretty paper you are turning out."—Geo. H. Guy, New York City.

CONSOLATION.

When the rash contractor waileth for the work that has gone wrong,
When he weeps to know that the profession know it;
O, let him sweet nepenthe seek in this consoling song,
And if he feels like swearing, simply "blow" it.
For though his name may raise the jest among those in the know,
And though his stock may swell and make him tearful:
It's a very, very evil wind that good to none doth blow,
And his trade competitors will feel more cheerful.

When Demon Fog is choking us, when black the air and sour,
When life is dark and dismal as a prison,
When speech is blindly sulphurous as fumes which overpower:
O, think what lovely load curves have arisen!
And sense the joy of station chiefs and those who hold the scrip
Of lighting works: you bet there's no repining:
For if there's silvery edging to the cloud, you take my tip,
To the fog there is an eighteen-karat lining.

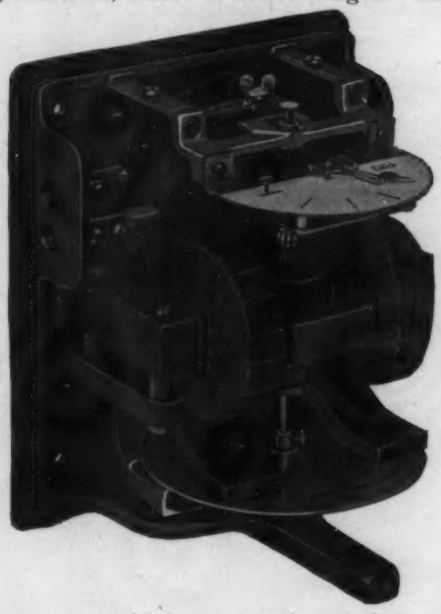
Ho, all you central-station men who work the mid-day shift
On Saturday, the 25th of December,
Refrain from letting feelings into profanation drift
Because of this; but thankfully remember:
That turkey's indigestible, mince-pies would make you ill
(The fox that hated grapes may serve as warning),
You'll miss the black draught afterwards, you'll miss the loathly pill,
And you'll miss the going to service in the morning.

—"J. H. C. B." in London Electrical Engineer.

A STORAGE BATTERY WATTMETER.

The increasing application of storage batteries, consequent on their perfection, to electric light and railway station use, as well as to street cars, motor carriages, electric launches, etc., where a portable source of power is requisite, has led to the development of a special type of the Thomson recording wattmeter which will show at a glance the amount of energy available in the battery. Their new Thomson recording storage battery meter, as it is called, resembles in general appearance, the standard Thompson recording wattmeter, and is, in fact, a development from it, the mechanism being almost exactly similar. The accuracy and durability characteristic of the standard type have both been maintained, while additional precaution is provided with a single indicating needle moving over a horizontal semi-circular dial.

The essential requirement for a storage battery meter is that the armature shall rotate in either direction and give equally accurate readings in both. In this meter this requisite is fully preserved. The energy put into the cells, is, therefore, added to the reading of the meter,



while the energy withdrawn is subtracted, but to compensate for the loss in the cells the meter runs more slowly when charging. The reading of the meter represents not the amount of energy put into the battery, but the amount available and when the needle points to zero on the dial it shows that the battery is completely discharged.

For motor carriage, street car and electric launch service a meter of this charater is a most necessary adjunct. Indeed, any of these vehicles of transportation not equipped with a device to warn the operator of the amount of current available to carry him forward on his journey or to bring him back to his starting point, would be incomplete. Without it he is absolutely ignorant of the power upon which he can depend, and would run serious risk of finding himself at a stand still far from home with no means of getting either forward or backward without recourse to some mechanical method.

The durability and efficient operation of storage cells being maintained by re-charging them before they are exhausted, the only method of learning of their exact condition is by a meter ofthis character. The cells being recharged at the right time, thegeneral result is a much higher battery economy.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

MR. J. W. BROOKS RETIRES.

The Brooks-Follis Electric Corporation has issued the following self-explanatory announcement under date of April 30th, 1898:

"We beg to inform you that, from May 1st, 1898, the management of the Brooks-Follis Electric Corporation will be under the charge of Mr. Thomas H. Van Frank, as manager, business interests in the East compelling the retirement of Mr. John W. Brooks.

"We trust that you will extend to us, under the new management, the same valued consideration as in the past.

"Very truly yours,

"BROOKS-FOLLIS ELECTRIC CORPORATION.

"Jas. H. Follis, Pres."

A PERFECTED ENCLOSED ARC LAMP.

Since the introduction of the enclosed arc lamp, the large quantities used and the positive endorsement of Central Station operators of large experience has been so marked that but little need be said comparing it with the lamp of the open arc principle, which is rapidly becoming obsolete.

The life of the carbon has been increased fifteen times over the open arc, which means increased economy in material and attendance. Although it is advisable to use an imported carbon in the enclosed arc lamp, the cost of carbon renewals in the Pacific Arc Lamp is less than incandescent lamp renewals for the same amount of light.

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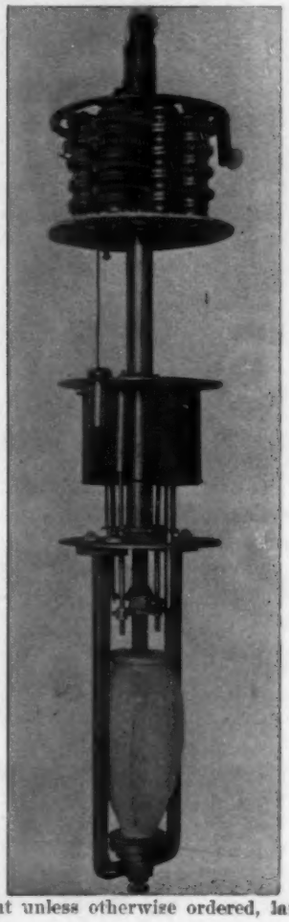

The inner globe which entirely surrounds the arc, acts as a perfect spark arrester; this feature of perfect safety from fire has caused the enclosed type of arc lamp to be endorsed by all boards of Fire Underwriters. The inner globe also renders the consumption of the carbon perfect and noiseless, doing away with the objectionable and annoying "hissing" of open arc lamps.

The potential on which an open arc lamp operates is from 45 to 50 volts. The principle of the enclosed arc lamp permit of it being operated singly on a circuit of from 95 to 125 volts; thus the wiring connection of the lamp to a circuit is much simpler and allows the lamp to be turned on or off independently of any other; in fact, to be installed and operated similar to an incandescent lamp.

The Pacific arc lamp, type "A," is designed to burn singly across a direct current circuit of the voltage above given at a current consumption of 4 to 6 amperes; or two arc lamps may be burned in series across a circuit from 190 to 250 volts, but unless otherwise ordered, lamps will be adjusted at the fac-

tory for a current consumption of 4½ amperes at a voltage of 110.

The canopy is made in polished brass finish or black enamel, the latter being recommended and it may be used for either indoor or outdoor service, for the latter the top of the canopy is covered by a small water sheeding shield or hood. It may sometimes be necessary to get at all the internal parts of the lamp; particular attention therefore has been given to the design of the canopy that it may be removed easily and quickly, entirely exposing the lamp's mechanism. For hanging the lamp by a cord, an insulated screw cup is provided, which can be removed if the lamp is to be screwed to a stiff metal drop.

A potential of from 70 to 80 volts is maintained across the arc. In the upper portion of the canopy is the resistance coil and by cutting in or out the proper amount of resistance by suitable clips the lamp may be adjusted to burn on a circuit of from 95 to 125 volts.

Two globes are employed, one inside the other. The inner globe of special glass surrounds the arc, and is capped at both ends; complete combustion of the carbon being obtained by the admission of the proper amount of oxygen. The outer globe is a ball 12 inches in diameter, with 5-inch opening on top, entirely closed on the bottom. This globe is supported by the canopy, no lower metal support being used, hence all possible light is obtained directly underneath. A metal ring is permanently attached to the neck of the globe by thumb screws; this ring engages in the canopy by a clip, thus the globe may be easily and quickly removed without loosening the thumb screws. Chains of suitable length support the globe while the lamp is being trimmed. As a result of long experiments, the use of an opalescent inner globe and light frosted outer globe is recommended as giving the purest and finest light.

The mechanism of this Pacific arc lamp is unique and differs radically from anything on the market and its remarkable simplicity and fewness of parts recommend it strongly. It is of the lever clutch feed type; the clutch being entirely insulated from all parts,, hence no arcing is possible between it and the carbon. No carbon rod is used. No gearing or wheels or set screws are employed. The arc is broken magnetically and fed by gravity, and being inclosed there is no liability to accident from insects or accumulation of dust.

No springs are used, as it is well known that the resilience of a spring is affected by changes of temperature, for which reason the adjustment of lamps using springs is difficult and very unsatisfactory as a fixed temperature cannot be maintained. The Pacific arc lamp is therefore independent of temperature changes and on one trimming, the lamp will burn about 150 hours. Special imported carbons are employed, the upper carbon being 12 inches long, and the lower carbon 6 inches long, both carbons being one-half inch diameter.

In recapitulation, the Pacific arc lamp has no set screws to maintain adjustment; it has no carbon rod, no springs, no wheels, or gearing, and no shadows. The lamp has the fewest parts of any lamp made, it is of graceful design, perfect in workmanship, produces a perfectly steady light and is easiest to trim of any on the market. It is moreover, the finished product of a purely California concern, well deserving of patronage.

Manufactured and for sale by the Pacific Arc Lamp Company, 23 Stevenson street, San Francisco.

A TREATISE ON LIGTHNING ARRESTERS.

"Lightning Arresters," is the title of a short treatise from the press of the General Electric Company, descriptive of the devices which it has developed for preventing injury to electrical aparatus by lightning. The introduction is a short examination of the qualifications necessary to a perfect lightning arrester, with a short disquisition on the special advantages of the magnetic blow-out. This is followed by concise descriptions of the arc and incandescent station arresters, already well known as types "A," "AA" and "B." Greater space is given to the more recently developed lightning arrester for direct current circuits up to 850 volts, and to the G. E., short gap arrester, especially designed for alternating current circuits and in use on almost all of the great electric power transmissions of the West. The booklet is well written and printed, the illustrations are excellent and the diagrams of connections clear and distinct. We understand that "Lightning Arresters" will be furnished by the Supply Department of the General Electric Company on application at any of the sales offices.

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